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FUTURE Digital Edition

SEE HOW DEEP THE RABBIT HOLE GOES

PLUG BACK INTO THE MATRIX

Original Release Date: 3/31/1999

Worldwide Box Office: $466 Million

NEO
(The One / Mr. Anderson)

Neo, the sixth incarnation of the One, a man born inside the Matrix who had the ability to change whatever he wanted, to remake the Matrix as he saw fit.

Keanu Reeves was 33 during the filming of *The Matrix*.

PILLS
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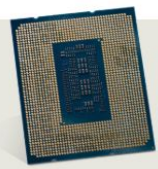

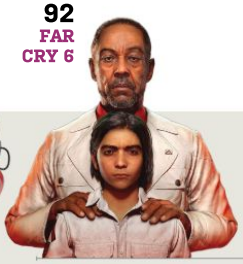

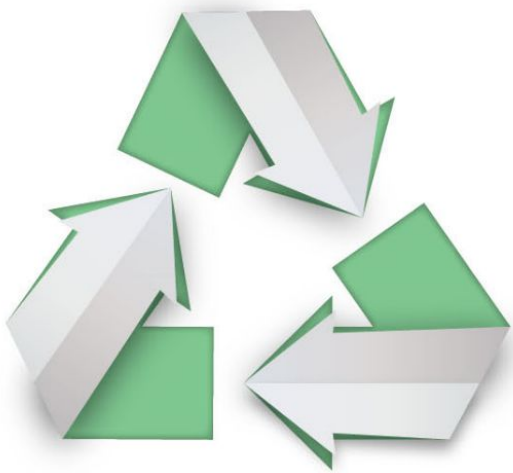

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Zak Storey

ALL GOOD THINGS

WELCOME to our final issue of 2021. What a year it's been, filled with crazy ups-and-downs, and still stuck in the middle of a pandemic that refuses to budge. But before we get on to next year, next issue, and our predictions for what's going to happen in the world of tech in 2022, we need to wrap up these last 12 months in style. To that end, this edition of the mag is jam-packed with a ton of epic content to really celebrate this orbit around the sun. We have the annual *Maximum PC* Gear of the Year awards, a guide on how to get into PC modding from our own resident system-building guru Kris, a full explainer on how supercomputers predict the weather and earthquakes from Ian, and a fantastic history of image editing and graphic design as well from Sam.

If that doesn't take your fancy, there's also a kick-ass $5,000 transplant build inside of the NZXT H510 Flow chassis (admittedly half of that cost is the GPU), a ton of tutorials, including setting up a guest network to manage your Smart Home devices, and enough reviews to keep even the most eager of hardware enthusiast happy. Including a first look at Intel's latest and greatest Core i9-12900K Alder Lake processor. Plus, there's even more goodness from the likes of our regular columnists, news-writers, and team members too.

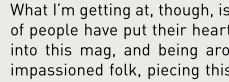
Sadly, however, this is also going to be my final issue as Editor-in-Chief of *Maximum PC*. By the time you read this, I will have left the team for pastures new. Working here has been an incredible journey. I remember the first day I started, sitting down next to Alan, grinning like an idiot, surrounded by crazy amounts of hardware, meeting our Art Editor, Fraser, for the first time and being introduced to his ridiculously eclectic music taste (seriously, it's something else), and of course being thrown in at the deep-end a day later, on my own, at the launch event for the GTX 980 Ti, where I had absolutely no idea how graphics cards worked as they proceeded to do a two-hour deep dive on the Maxwell GPU architecture.

Since then, time has flown by. Reviews ed, Deputy ed, a move to *Tom's Hardware*, then coming back as Editor. Working with Tuan, Jarred, Jimmy, Jeremy, the two Alexs, Joanna, Katharine, Christian, Ian, Nick, Chris, James, Sam, and Jon has just been awesome. They're some exceptionally talented people, and I can't praise them all enough. Of course, I'd also like to thank the guys in the photography team, without whom we couldn't do what we do, particularly Olly, who's put up with me over the years, dealing admirably during the insanity-inducing week-long Dream Machine shoots.

I'm sure there are more people I should mention, but word counts have always been the bane of my existence! What I'm getting at, though, is that a lot of people have put their heart and soul into this mag, and being around such impassioned folk, piecing this together each month, has been an honor.

I hope you enjoy the latest issue, it's been a blast to produce, and I'm looking forward to reading the next one too, as I am positive the new editor is going to do a standout job. Until then!

All the best,



Zak is Maximum PC*'s editor-in-chief and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: editor@maximumpc.com

THE NEWS

Intel goes hybrid

Alder Lake brings big changes to Intel's desktop chips

WE HAVE been waiting for what seems like ages, but now Intel has finally introduced its Node 7 process, and it has gone hybrid: welcome Alder Lake, the 12th Generation of desktop processors. Intel calls this the "biggest ever leap in our x86 architecture". Alder Lake uses a mix of high-performance cores (P-cores) using the Golden Cove architecture, and high-efficiency cores (E-cores) using the Gracemont architecture. It's a sound idea that has served Apple's M1 chip well.

Meanwhile, AMD has stated that it is sticking to its single-core type designs, for now. AMD also has patents covering hybrid architecture, so the option is on the table.

Initially, there are six versions of Alder Lake, with another 28 versions to follow. To start though we get the Core i5-12600, i7-12700, and i9-12900. Each comes in two versions: K and KF. Both are unlocked, but the KF lacks the integrated graphics core. The i5-12600 has six performance and four efficiency cores, a base clock of 3.7GHz with a boost to 4.9Ghz. The i7-12700 adds two performance cores and has a base clock of 3.6GHz. The halo i9-12900K has eight of each core, a base clock of 3.2GHz, and a top boost of 5.2Ghz. Each performance core gets 1.25MB of L2 cache, while the four-core block of E-cores shares a 2MB cache. Over this sits either 20, 25, or 30MB of L3cache. All have 20 PCIe lanes, 16 PCIe 5.0 lanes for graphics, and four PCIe 4.0 lanes for speedy storage.

All this technical wizardry costs $264, $384, and $564 respectively for the KF versions, saving $25 over the regular K versions. It's a small bump over the outgoing 11th-gen chips but compares well to the equivalent Ryzens. Although the top chip looks like an expensive proposition, Intel never seems to have trouble selling its hottest chips.

Alder Lake officially uses the Intel 7 process, which means it equates to 7nm, sort of. Actually, it is a development of Intel's 10nm process, which is physically similar to other 7nm process chips. Another metric that has changed is the Thermal Design Power numbers, which were always an approximation. Now we have Processor Base Power (PBP), and the Maximum Turbo Power (MTP) for when you are running full bore. All have a PBP of 125W, and MTP numbers of 150W, 190W, and a startling 241W. We also have DDR5 support, with dual memory channels with a maximum of 128GB. DDR4 support is retained. A new chip also means a new board. Alder Lake uses an LGA 1700 socket, and we've just one chipset so far, the Z690.

Intel's 12th-gen desktop chip has had a complete overhaul of the processor architecture.

How fast is it? Intel claims an IPC (Instructions Per Cycle) boost of 1.15 (or 1.19 if 'unadjusted'), which is a solid performance bump. All eyes will gravitate to the i9-12900, and how good a gaming chip it is (see our full review on page 76). To accompany the launch, Intel produced a set of slides highlighting the performance, and while they were carefully picked to show the chip to its advantage, they made encouraging reading. Those E-cores also help push multi-threading performance considerably, in some cases the 12th-gen chips are up to 40-50 percent faster than the previous ones. These small cores are still pokey CPUs in their own right, each is more powerful than a Skylake CPU, and the i9-12900 has a total of 24 threads to play with (only the P-cores have Hyperthreading).

When Intel releases a new halo chip, you know somebody will push it to the extreme. One modder has attached liquid nitrogen cooling and turned it up to 6.8GHz on the P-cores, and 5.3GHz on the E-cores. Geekbench 4 and 5 were run, and world records duly set, after turning down the wick to 6.7GHz for stability. Fun, pointless, but it had to be done.

One fly in the ointment is DRM, which uses CPU checking. These aren't expecting a hybrid architecture and can fail. Any supported game can be patched, however older games might not work. We'll have to wait and see, but it would be a pity to lose your favorite games when upgrading.

Alder Lake needs to go well for Intel as it has been chasing AMD's tail for a while. Strong competition helps push development, so over the next year we'll see a lot more Alder Lake stuff, including more motherboard chipsets, and new 'P' and 'M' dies for the laptop and mobile markets. Let the games begin. **–CL**

> "Alder Lake needs to go well for Intel. It has been chasing AMD's tail for a while now.

© TOM'S HARDWARE

ALEXA IS LISTENING

AND WRITING IT ALL DOWN FOR LATER USE

SMART SPEAKERS, or digital assistants, have been a huge hit. There are over 90 million of them in the US, and by 2025 it is expected that three-quarters of homes will have at least one smart device. And all of them are gathering data. It transpires that Alexa is the most adept at this. A new report from Reviews.org looked at all the major players to see just what you are giving away to their parent companies.

The top five all collect the basics: your name, time zone, phone number, location, and IP address. Some dig a little deeper, including your address, payment information, age, and personal interests. The best at this is Alexa, which collects this and more, including your voice characteristics. It also delves into your profile and tracks your buying habits.

Another recent study looked at 48 data points and found that Alexa recorded 37 of them. We know data is being collected, but to see it laid out clearly is sobering stuff. Your data is worth something, as Silicon Valley big cheese and founder of VR, Jaron Lanier noted, "if it's valuable, you should get paid for it". Now there's an idea. **–CL**

WIN11 SE TO LAND NEXT YEAR

A cut-down version for your school laptop

WONDERFUL AS IT IS, Windows is no lightweight OS, which is something of a liability in a world where smartphones, tablets, and other mobile devices outnumber PCs considerably. Enter Win11 SE, a cut-down version aimed at the school laptop. Builds of Win 11 SE have been leaked online, but the official release is set for 2022. The leaked version has a few features disabled, including customization settings, but isn't a final build. It will come ready-installed in a range of budget-friendly devices, such as Surface laptops, but isn't a replacement for Win11 Education Edition, a version designed for school PCs. Bringing the Windows experience to smaller devices has been a Microsoft goal, but it cannot be shoe-horned onto anything smaller than a laptop without compromises. In a recent interview, Bill Gates said Microsoft's failure to catch the smartphone OS market was "his biggest mistake". **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

FCC EYES SPAM TEXTS
The FCC is looking to make mobile carriers block spam texts. A staggering 7.4 billion were delivered in March 2021.

BIGGEST BUG BOUNTY YET
Immunefi paid a researcher $2 million for discovering a bug on a finance platform that put $850 million of cryptocurrency at risk.

STEEL WOOD
Scientists have found a way to make wood tough enough to take an edge better than a steel knife.

TRAGEDIES

AMAZON'S PRACTICES
Internal documents prove that Amazon copies popular items then fiddles with search code to promote them over rivals.

FACEBOOK UNFOLLOWING
A developer who built an extension that enabled you to empty the News Feed has been banned from Facebook.

BITCOIN POWER
Half of Bitcoin mining is carried out by just 50 miners. The top 10% of miners control 90% of it.

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APPLE'S NEW SILICON

Two versions of M1 chip land in MacBook Pros

A LITTLE OVER a year ago, Apple's M1 processors arrived, and from nowhere Apple entered the processor market with a chip that was touted by many as a real rival to x86 silicon. Now it has returned with two new versions: the M1 Pro, and the M1 Max. These two ARM-based SoC designs build on the original but are much bigger beasts. The M1 Pro has eight high-performance cores, double that of the original M1, plus two high-efficiency cores. These are coupled to 14 or 16 GPU cores, again twice the original number. There's 24MB of L2 cache, a 16 core Neural Engine, and up to 32GB of unified memory. This adds up to a total of 33.7 billion transistors. The M1 Max is the true monster, with 57 billion transistors. It has the same processor core count as the M1 Pro, but with 24 or 32 GPU cores, and up to 64GB of unified memory. Much work has been done to improve the memory bandwidth. The original M1 managed 68GB/s, the M1 Pro jumps to 200 GB/s, and the M1 Max doubles this to 400GB/s.

On paper, the M1 chip is a proper rival to the blue and red teams. Initial benchmarks show it can keep pace with Intel's best. In floating-point calculation, it does more than that, due to the memory bandwidth. These chips can even give the best desktop machines a hard time. Perhaps more impressive is the amount of power required to do this. Running a punishing benchmark such as Cinebench R23 an M1 Max laptop draws around 40W. A system using a top-flight Core i9 will chew through more than twice that. High performance usually means high power consumption, Apple has managed one without the other.

Should Intel be worried? The M1 will only be a rival in terms of numbers if Apple starts selling to other manufacturers, and building more affordable rigs. There's no sign of that happening, but it does give Apple impressively quick machines. The M1 chips make their debut in the new 14-inch and 16-inch MacBook Pros which start at $1,999 and rise to $3,499. **–CL**

YOU DO HAVE THE RIGHT TO REPAIR

You can legally open it up and fix it

IF YOU OWN SOMETHING you might imagine you have to right to take it apart, modify, or repair it. You don't. Often the job is made difficult because you need special tools or software, but the main problem is copyright law, specifically the Digital Millennium Copyright Act, which has numerous exemptions and allows security measures to prevent you from tinkering. This stops you copying abandoned games or cracking open your smartphone.

These exemptions are made by the US Copyright Office, reviewed every three years, and signed off by the Librarian of Congress. The latest changes include recommendations from iFix, and the Electronic Frontier Foundation (EFF).

Over the years, there has been a slow swing away from restrictive practices, and the latest batch of changes goes further than usual. It is now legal to fiddle about with any consumer electronics device controlled by software, as long as it is for diagnosis, maintenance, and repair. That's good news, although there is a caveat on game consoles—the new rules only cover the optical drive.

Covering consumer devices it excludes one vocal group who really want to fix their kit: the owners of John Deere tractors, who are still denied vital tools and parts. It also doesn't mean manufacturers will make it easy for you either, cases will still be awkward to open and parts inside difficult to replace. The EFF didn't get everything it wanted, such as modifying items to accept third-party parts. Still, it's a step in the right direction. The three-year cycle of exemption review is cumbersome, however, what's needed is some solid legislation that bakes the right to repair and modify into consumer law. Can we at least have access to detailed manuals and spare parts? **–CL**

Goodbye Facebook, hello Meta

FACEBOOK HAS A NEW corporate name: Meta. There's a new logo too, a squished blue infinity symbol, or pretzel. Meta means 'beyond' in Greek, and according to CEO Mark Zuckerburg, it symbolizes that "there is always a next chapter to the story". The company's timing isn't perfect, embroiled as it is in controversy over its business practices, however, the bad publicity had "nothing to bear on this", says Zuckerburg.

Meta also unveiled its new project: the metaverse, "the future of the internet". Essentially, it's an interconnected digital world where your avatar can interact with others, as well as carry out all the usual tasks you can on the internet. The word first appeared in Neal Stephenson's 1992 novel *Snow Crash*, as a place people could escape a less than perfect real world. The idea of building a metaverse for real has been knocking about Silicon Valley for ages, see the game *Second Life* for example.

The promotional video for Meta's metaverse presents a flattering picture, as Zuckerburg's avatar floats around a digitally clean world. Plans include the integration of blockchain technology, an economic system, and immersive VR—plus lots of commercial activity and data gathering, presumably. Meta has poured about $10 billion into the project this year already, but among the exciting stuff and rich possibilities, is one obvious problem: do we want such a potentially powerful digital property run by a company with a questionable record in looking after people's true interests? Interesting times indeed. **–CL**

The metaverse is a bold project with lots of potential, but are we ready for it?

No Ink? Then you can't scan

Somebody has called Canon out on its business practices regarding its all-in-one printers: if they are out of ink they won't scan or fax. The dissatisfied customer launched a class-action suit against Canon, seeking $5 million in damages for false and misleading advertising.

Canon says "these precautions are in place to prevent damage to the printer", but there's no technical reason, just the desire to sell more ink. Despite numerous protests, it appears that it is going to take legal muscle to stop the practice. The plaintiff is pressing for a jury trial, which might be fun, given how much people love buying expensive printer inks. **–CL**

Robot dogs with guns

At the US Army's annual conference Ghost Robots revealed a Vision 60 robot 'dog' with a custom sniper rifle, turning an endearing invention into something distinctly menacing. The military has been experimenting with robot dogs for years, but this is the first time it has armed one. The dogs use AI for various functions, but it is stressed that the gun mounting will be remotely controlled.

The United Nations is currently seeking a ban on lethal autonomous weapons systems (LAWS), but negotiations were interrupted by the pandemic. At some point, we need to decide if we are happy with a computer deciding to pull the trigger because we now have the hardware to do it. **–CL**

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Jarred Walton

TECH TALK

Windows 11's HVCI and VBS Performance Penalty

WINDOWS 11. The mere mention of those two words is enough to cause plenty of pain and suffering to computer enthusiasts everywhere. Now we're stuck trying to decide between the new UI and improved security or sticking with the old and trusted Windows 10 for the next four years.

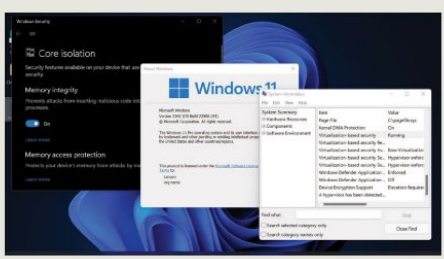
If the cosmetic changes weren't enough to make you reconsider upgrading, the TPM requirement and reduced performance might do the trick. Windows 11 comes with VBS—that's Virtualization Based Security, not Visual Basic Script. It isn't new, having first been introduced to Windows 10 back in October 2019 with the 1903 9D update, but the chances are you never actually used VBS with Windows 10. In short, VBS creates a secure area in memory for other security features to use. These include TPM (Trusted Platform Modules) and HVCI (Hypervisor Protected Code Integrity).

The problem with these security features is that they reduce overall system performance by roughly five percent—the equivalent of one of Intel's CPU architecture upgrades (with the number of cores and threads static). Gaming is a prime candidate for reduced performance as the security features can add latency to memory operations.

While HVCI would normally impact performance more than VBS, processors starting with Intel's 7th Gen Core and AMD's Zen 2 chips also support Mode Based Execution Control (MBEC), which reduces the impact of HVCI, but is still around 5–7 percent performance loss. The loss may be even greater on older CPUs, with Microsoft recommending at least an 11th Gen CPU if you intend to use VBS. That counts 95 percent of people out.

There are many questions regarding VBS, including how to turn it off. One simple solution that may suffice is to just disable virtualization support in your system BIOS. There are registry edits and Windows settings that can be used to disable VBS as well, but some people seem to have trouble getting those to work.

One interesting point is that people who upgrade from Windows 10 to Windows 11 generally won't need to worry about VBS and HVCI, as they're disabled by default. However, if you do a clean Windows 11 installation, you'll want to check if they're enabled. Thankfully, that's easily done.



Welcome to the wonderful world of Windows 11. Please keep your hands and feet inside the ride at all times

Open your System Information app (just type that into the search bar), then look for Virtualization-based security. If it's off, you're all set—unless of course you want the added security and are willing to suffer the performance loss. If you find that VBS is enabled, turning it off can be a bit trickier, depending on your PC. Open the "Core Isolation" setting in Windows Security, toggle that off and reboot, and check System Information.

If that doesn't work, open Regedit (the registry editor) and navigate to HKEY_LOCAL_MACHINE\System\CurrentControlSet\Control\DeviceGuard. Open "EnableVirtualizationBasedSecurity" and set that to 0, reboot, and that should take care of things. If you want VBS enabled, then do the opposite.

Because I'm a glutton for punishment and like to try out new things, I'll be working on more in-depth testing of Windows 11 versus Windows 10 in the next issue. But given the rather stringent hardware requirements for a proper Windows 11 installation—you need at least TPM 1.2 support, which rules out first-generation Ryzen CPUs and earlier AMD processors, and typically means you need at least a 6th Gen Intel CPU—there will undoubtedly be plenty of people sticking with Windows 10 for a while, including most businesses.

In other words, it feels like the "skip every other generation of Windows" mantra remains. Windows 11 may join Windows 8 and Windows Vista in infamy.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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TALKING

BY ZAK STOREY

Third Culture Kids & The Internet

Maximum PC talks all things TCK & Social Media

This issue, we reached out to Kelly Joeman, Senior Manager of Audience Development at One Animation, to learn about third-culture kids, and how she developed her Instagram platform into a thriving educational community for ex-pats, migrants and others.

Kelly Joeman has worked across multiple YouTube brand channels over the years, and is also a champion of the TCK community on Instagram.

Maximum PC: Hi Kelly, thanks for joining us! So, to start out, could you explain a bit about yourself, who you are, what do you do?

Kelly Joeman: Sure! I'm Kelly and I'm a senior manager of audience development for One Animation. I manage the digital platforms for kids' shows, I run YouTube channels for different brands and I've recently moved to Singapore, which has been quite a big transition for me.

MPC: What is a TCK? Can you explain what that is? Is it just another name for an ex-pat, or is it more in-depth than that?

Kelly: So, basically, a third-culture kid is an individual who has grown up amongst different countries or spent a significant part of their developmental years growing up in countries and cultures other than that of their parents' culture or their passport culture. The term has expanded recently because there has been an increase in social mobility and moving around the world. Of course, that means cultures are coming together and so you get more cultural mixing.

The larger umbrella term now is 'cross-cultural kids', and that encompasses groups such as migrants, children of migrants, or ex-pats—you know, multilingual, multiracial, and everything in between. Essentially, third-culture kids are kind of part of that bracket, so the term is quite complex.

I like to visualize it as a sort of Venn Diagram. Basically, you have your first culture, which is sort of your home culture, and then your second culture, which is the host culture—that's the culture of the place that you have been brought up in. And then the third culture is this more abstract thing, like a culture of shared commonalities that people have when they're mixing.

MPC: Interesting, so can you give us a bit of background into your upbringing? Basically, what makes you a TCK?

Kelly: I'm half English and half Malaysian, and I grew up in both. I moved to Malaysia when I was nine and I did some school there, I did a bit of primary and a bit of high school there, and then I moved back to the UK when I was 18 to study at college and university.

I spent a significant part of my developmental years in Malaysia, a country that has some quite different customs and cultures compared with the UK. So my experience of culture is very much a hybrid and I associate or construct my identity with different parts of both those things.

Also because I went to an International School out in Malaysia and met loads of different people from all over the world, that helped to shape me as well, because it really depends on the types of people you're mixed with, essentially. And yeah the cultures all just kind of get smashed together, which is great.

MPC: Something we've seen a lot in our research is this big question of what exactly 'home' means individually to a TCK? Can you explain how that's different compared to say someone who's born and raised in the USA?

Kelly: Basically, 'home' is kind of an abstract concept if you think about it, because your identity is closely related to where you think of as home. But with a third culture kid, if they've moved around quite a lot, then they don't have

The TCK community on www.instagram.com/_thirdculture/

that one fixed place that they would link to being home for them and 'home' could be a multitude of places.

Most often, what I find when I speak to other TCKs or people that are featured on my page, they always talk about home being more a place where their friends and family are. Wherever their friends and family are, that's where they would call home. They will tie all of their memories and experiences to these more abstract things, which maybe helps them to shape their identity a bit more. But that's how I would differentiate it.

MPC: You mentioned that you have a page there, can you expand on that a bit? What do you do in regards to the TCK movement?

Kelly: I have an Instagram community (@_thirdculture) and I always like to say it's basically a 'Humans of New York-style' page. I compile the stories of people from all over the world and of all different ages as well. You know, it could be like multicultural families, or it could be third-culture kids growing up in various countries across the globe, and I share their stories.

I curate posts, so I'll design, some text posts too, as well as pictorial posts. Those text posts will either be quotes that people can relate to, or they might be quotes that have been taken from stickers and stories, for example. I do a lot of polls and 'ask the audience' on my stories and it will be things like: "how would you deal with homesickness?", "what's some advice that you would give to your younger self?", or "what's some advice that you give to fellow young kids who are going through the transition of moving between countries?" I try and make it as relatable as possible.

It's a great hub for TCKs, but it's also intended to be sort of an educational platform as well, a page for those who maybe don't know about the concept. I found that, especially during the pandemic and like the last few years, there have been a lot of ups and downs, political unrest, and stuff like that, especially in terms of cultures mixing and how people view each other in their society.

So for me, the Instagram community has been a great tool to teach people about the benefits of mixing cultures and how important it is to be open and to just be curious and want to learn about different people in different places.

MPC: What prompted you to start your TCK page, to begin with? How did you get it going?

Kelly: I've always toyed with the idea of talking about third-culture kids and educating people in such a way, I just never knew what avenue that would take. Basically, I was always on social media anyway, I mean, I love flicking through Instagram. You know, I feel like when you're starting off anything, it has to be a place that you are naturally gravitated to anyway.

So whatever platform that you want to kind of establish yourself on, if it's a blog or a podcast, you need to make sure that you understand the way that platform works. If you naturally use it anyway, then it makes your life a lot easier, rather than having to do that extra step of login and kind of learn about it.

So, it was initially a project between my friend and me, because we were on the executive committee of the Third Culture Society at Warwick University, which was a really fun society, and that was the first time I'd learned about the term.

I was vice-president at the time, so I was doing the marketing and I found it really interesting like, how do you market a concept that's so niche and there are so many people that could fall under that bracket, but maybe they haven't had the right exposure to it or they didn't know about the term before? And how do you remain inclusive to everybody at the same time?

For me, it was like: 'OK, this is a project that we want to start, so let's find the right platform for it, and let's try and optimize our SEO and find the community that's out there'.

I found that Instagram was the best place for it, so I started making content, sourcing stories from friends and family who had these similar experiences to me growing up in International School and even back at university. Then I started working on quotes because I like to design stuff as well, so that was where it all began.

And then, yeah, it just took off because, luckily, I kind of fell into it at the right time when there were only a few TCK accounts out there. Personally, I found that they were a little bit, not quite negative, but sort of mixed. I wanted to present a more positive, vibrant feed and I wanted people to engage with the content in a different way and be inspired, rather than be looking at the negative or the less rosy aspects. So, for me, it was a good way of cracking into that space.

MPC: What kind of feedback have you been getting from the community? Obviously, it's still a growing platform, so how have people responded?

Kelly: They've been amazing. I found that when you start to create a community, you get loyal followers that engage with your posts and they want to help you as well. So there has been a buzz around things like they want to create a dating app, or they want to take it further than just this one page and I think that's great.

Initially, I had a bit of pushback because there were a couple of followers, and I don't know if people find this as well, but sometimes your most loyal followers are also the harshest in terms of the way they give you feedback. But it's something that you should take on board because they're obviously engaging with it as they're giving you their opinion. Some of the feedback I got initially was like that. That it was too rosy, or too perfect, like that there wasn't enough of that well-rounded, all experiences kind of thing. Because when you're a TCK, there are good and bad aspects, so you could say: "oh yeah, it's great. We're mixing cultures, we can fit in everywhere. We can blend

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in with different types of people and we have an open outlook on life" and you can unite people that way. But sometimes, there are the negative aspects of the TCK experience, where it's like, 'yeah, I don't fit in everywhere' or 'I want to be seen as a local in this place because it's my birth country, but I don't look or sound like everybody else'. Then people will put labels on you and that can be quite alienating in some ways.

We all want to get to a stage where we're comfortable in our own skin or in the community we're in and want to feel accepted. Now, I'm much more conscious of putting out stories, and when I ask people for submissions or people approach me, I'm always conscious to say just be open and unfiltered. Be honest and we can work with that. Maybe there's a kid out there reading this and thinking, oh, that's me, I identify with this and maybe they can learn from your story as well.

MPC: What are you hoping to achieve with this? Is it a long-term business idea or is it just more altruistic or a hobby? What's the long-term aim?

Kelly: It started off as a passion project because I wanted a space where I could build that community and people would gravitate towards it and feel comfortable enough to share their own experiences. But it's also a great kind of... it's almost therapeutic for me too, because I have gone through those similar journeys.

And to understand myself and my own identity, it's always great to be challenged and be changed by the process of running this page and interacting with so many people all over the world. I would say that it'd be great to move it into some more tangible space. I'd love to do a coffee book or something. Or compile all the stories together and put them out there in some form or another.

A lot of people actually find it quite soothing and comforting to send in things. I've had so many random stories. There was this mixed-race girl and she was trying to adjust to life with her husband in Germany, but never quite fitting in, and people will send stories in like that and I would give them advice.

I don't know how that would translate into a more tangible project, but I'd love to see how else I could support the community in mental health awareness, for example, because a few people have reached out to me.

But, in terms of, like, putting it out there in more of a business, yeah, it could be a coffee book. Some people have talked about dating platforms. I feel like that's quite an interesting one, although obviously that would require a lot more work and a bigger team to really bring it to life.

Maybe, we could arrange some more events because I hosted one in London fairly recently. That was really exciting to actually bring people together and make it more of a real-world experience. Doing more stuff like that would be cool.

MPC: What do you think it is that makes a successful social media presence? Are there any secrets you can share given your work background, or is just as simple as committing to producing daily content?

Kelly: It's a good question. People always say that consistency is key, and I would say that it is most definitely. I'm going to go off on a massive tangent here, but I think platforms such as YouTube now have begun to recognize and understand that you can't be creating 24/7 because that just leads to creative burnout. People are wary of this when they first start out, because they're like, 'oh yeah, I don't want to experience that', but it's far better to pace yourself and make sure that you have content stored up. It's better to release one type of content a week than feel the need to release something every single day. You might want to create a backlog for every single day and then schedule it in advance. But I think it's just about pacing yourself and understanding your strengths and limitations in terms of what you can and can't do.

Some people fall into this trap of needing to please the audience all the time and put out stuff that people are just going to click on really fast. But I think people can tell whether you're being authentic or not, and I would recommend that they don't just make a video just for the sake of making one.

I would always create a video if I see a trend that really fits the audience. Or even product-wise, if I see something that I think is a good fit with my audience and people will engage with it then fine. But if not, then I'm going to stay away from it. I think it's important to remember that people will recognize authenticity in your content.

I would say definitely be consistent, and when you're creative—sometimes there will be times when you're really motivated to create something and you've got a million and one ideas—then I would say just put it all down on paper, brainstorm and think about what you want to do. Then if in the next couple of days or the week after you're like, 'oh, I can't think of anything new', just try and experiment, try new things.

It doesn't matter what platform you're on because every platform has a certain algorithm that you want to appease, but at the same time there's always scope for, well, as they say, 'going viral'. It's more about just trying something different and if it takes off and people really resonate with it, then you've done your job, right?

But you shouldn't rely on those things to get you through, you can still put out regular content that you want to put out kind of thing.

MPC: For a lot of people having a full-time job and then coming home and spending time setting something up like this, it's a challenge. There are all those extra responsibilities, your partner, kids, family, friends, so is it hard to balance that against your career and against everything else?

Kelly: It can be, but the lines of work I'm in, they feed into each other quite nicely. Where I'm looking at trends or competitors or algorithm changes in my current nine-to-five role, when I'm working on the project, on my third culture page, it doesn't feel too strenuous or anything. I'll be looking for those things at the same time, so I do feel like they tie in quite well.

But then having said that, sometimes I do take breaks where I won't post for a week or two, or have any fresh ideas. If I am having one of those weeks, I won't be too hard on myself, though. I'm just thinking, 'do it when you feel like it', and I think that's fine.

Social media platforms are now a lot more aware that there has been that endless loop of creating and then curating and then having to do it all over again. So now their algorithms are shifting in terms of like: 'OK, maybe we shouldn't be putting so much pressure on our creators' and I think that can only be a really good thing. Because it's to our advantage that you know you can take those breaks and not worry too much about losing that momentum, because when you do start to post, your content will always start to pick back up again.

MPC: Well, thank you for your time, Kelly! Is there anything else you'd like to add?

Kelly: Thank you! Of course, if anyone's interested, you can find our TCK community at https://www.instagram.com/_thirdculture/

Ian Evenden

TRADE CHAT

Compression, streaming, and internet connections

FAR CRY 6, INCLUDING ITS HD TEXTURE PACK, is a 50GB download. *Red Dead Redemption 2* is currently taking up 119GB on our gaming PC, and *Halo: The Master Chief Collection* is a little bit more. *Final Fantasy XV Windows Edition* and *Microsoft Flight Simulator* also take up almost 150GB each, whereas *Call of Duty: Modern Warfare* breaks the 200GB barrier.

I know, I should stop moaning, storage is cheap and I'm lucky to live at a time when the finest gaming experiences money can buy can be squirted down an internet pipe into my PC. But download sizes are outstripping the ability of our internet connections to deliver them in a timely manner.

According to Microsoft, over 20 million Americans live without access to high-speed internet connections. The chances are many of them are quite happy doing so. After all, the connected life is a special kind of punishment, with constant pings and buzzes having to be silenced and filtered out so you can get anything done at all.

However, the trajectory is only going in one direction—and that's toward greater and greater online confluence. The days of going to Blockbuster for your shiny movie disks are long gone, and while we understand it's still possible to buy a CD in a record store, we haven't been in one since the pandemic started.

Streaming is, essentially, a one-time download that's deleted instead of stored, so why do we still download games and software, rather than stream them? Size, mainly. Nvidia and the console manufacturers are all making strides with cloud gaming, and Microsoft has demonstrated a cloud-streamed version of Windows 11 that you can subscribe to. But streaming requires more of those always-on, high-speed internet connections.

> Why do we still download games and software, rather than stream? Size, mainly.

Here's a weird thing. *RDR 2* was 123GB before a recent 5GB patch, after which it was only 119GB.

An interesting blog post by Microsoft software engineer Jonathan Ready [https://bit.ly/MPC-squish] addressed the need to compress Windows updates in order to squeeze them down limited internet pipes, as a fully updated population of Windows boxes is a safer population, and MS has managed to shave 40 percent off the size of its updates.

The post goes into more detail than you ever could want about forward and reverse differential compression, but it got us thinking about how games are compressed as they come down the pipe.

Far Cry 6 says it's downloading 50GB and takes up 50GB on our drive. We know that Steam compresses its downloads, using the lossless LZMA algorithm (the same used in 7zip), and encrypts them using AES 256 if necessary, such as when you're pre-loading an unreleased game.

If you were thinking of decrypting one, 50 supercomputers checking one billion, billion keys per second would still need a number of years beginning with three and ending with 51 zeroes to brute force the 256-bit keyspace. Besides, AES is thought to be quantum-resistant as long as sufficiently large symmetric keys are used.

If we stream all our games and software as well as our media, then while the amount of data transferred may rise in the long-term, the short-term effect will be that individuals require a less powerful connection, as the need to download all the data before you start won't be there anymore.

Networking an entire country with fiber optics, including every mountain farm, lakeside fishing retreat, or ranch 300 miles from the nearest phone, will take a while. And another type of confluence, that of 5G or 6G mobile data and Wi-Fi, is likely to make that obsolete before long too.

Ian Evenden's first PC was a 286 with 640kb of memory. And who could need more than that?

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DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Corrupt memory
> Win11 on Mac
> Backup drive query

Random BSODs

I'm suffering from a weird problem that I hope you can help me fix. I am getting random blue screen errors when copying or moving files, and once in a while when I open too many browser tabs. I had one when I was syncing my Ancestry.com family tree to Family Tree Maker, when scanning a large downloaded file with McAfee, when trying to create an OS backup with Macrium Reflect Free and even while downloading a Linux ISO to create a live disc to boot from.

This problem has existed since I built the PC in October 2020, starting when I copied files from the old computer's drives to this one. It happens when copying files from external hard drives or flash drives to internal SSDs or HDD, internal to internal, or internal to external drives.

I am pretty sure this isn't a hardware problem. I can boot to a Linux live DVD (I used PCLinuxOS) and copy or move files without any problems. And I booted to a Macrium USB flash drive and created the OS backup without problems too. Western Digital's Dashboard shows all of the internal drives to be healthy. The external drives work fine with laptops. And I have to assume the cables are OK since I can copy files without errors when booting to a USB drive or Live DVD.

Before I format and reinstall, I wondered if you could come up with anything less severe. And I am a bit skeptical that a format and reload will fix this since it started immediately with a new build and installation.

—Dave Marshall

THE DOCTOR RESPONDS:

Seemingly random errors like this often point to faulty memory, particularly when there's no obvious pattern to when or how they occur. But first, we wanted to check the drives—not just to eliminate them as the cause of the problem, but also to ensure there weren't any problems as a result of all those crashes. Sure enough, when Dave ran Chkdsk on all the drives, errors were found and corrected. He also checked their SMART status to eliminate a rogue drive as the cause of the problem. Once done, we turned our full attention to the RAM.

Dave had already run the Windows Memory Diagnostic tool twice with no reports of errors, but we persuaded him to download and run the free version of Memtest86 from www.memtest86.com/memtest86.html as part of a more thorough check. Don't confuse the Passmark version with the open-source Memtest86+ that was forked from the original open-source project; sadly, Memtest86+ doesn't officially recognize the latest DIMMs. Sure enough, Memtest86 threw up so many errors with Dave's four sticks of 8GB Corsair Vengeance LPX DDR4-2400 CL16 RAM that it aborted the test with a big red FAIL.

Once you've identified a failure, you need to pinpoint which stick(s) of RAM are failing—Memtest86 can provide clues here. In Dave's case, it consistently reported errors in the "26G-28G of 32G" range of the installed memory. Sure enough, by isolating and testing each stick of RAM, Dave was able to confirm the faulty module was sitting in the fourth and final slot (#B2) on the motherboard.

As Dave's RAM was still under warranty, he got in touch with Corsair. It required him to test each stick independently in Memtest86 and then email the results of each scan as an HTML file. On receipt of the results, Corsair accepted the fault and authorized a return under guarantee of not just the failed DIMM but its matched pair. This ensures the replacements will be similarly matched.

Tagging issue in Plex

I recently allowed Plex to switch my TV library's scanner to its new Plex TV Agent. Since doing this, I have one of two choices: if I want to view specially tagged content (such as specials not covered by TheTVDB) then I must tick 'Prefer local metadata' under 'Manage Library → Edit... → Advanced'. However, this reveals that several of my regular TV shows have got title tags that have been added elsewhere. Where these tags exist, Plex uses these tags instead of the episode titles scraped from online databases.

So, if I untick 'Prefer local metadata', I get all the correct episode titles, but no tagged specials, but if I tick it, I end up with incorrect episode titles for some shows. I have various tagging

↘ submit your questions to: doctor@maximumpc.com

tools, including MetaX, but none of them seem to offer an easy way to remove existing tags, merely replace them with other tags. What's the simplest way to remove these tags? All my files are in MP4 format.

—Bryn Kolawski

THE DOCTOR RESPONDS: The solution is closer than you think, Bryn. You can strip title metadata from MP4 files using Windows Explorer. Once you've identified a folder containing these items, select all the files inside it, right-click them and choose Properties. Switch to the Details tab where you should see the Title tag has a Value, whether that's a single title across all files or, more likely, (Multiple Values).

At the bottom, you'll see a 'Remove Properties and Personal Information' link. Click this to open a new window. Here, select 'Remove the following properties from this file' and tick Title before clicking OK. A File Explorer window will open and each file will have its tag removed and then be saved. The process can take several minutes, depending on the file size, so be patient.

Once complete, click OK, then navigate to the TV show's entry within the Plex web interface. Roll your mouse over its artwork and click the vertical ellipsis button that pops up. Choose 'Refresh Metadata' and wait for the process to complete. Once done, navigate to the show that was displaying the wrong title and you should see it now displays the correct episode info.

Can't bypass login

I purchased and downloaded a new copy of Windows 10 Home. During the install process, I was forced to create a PIN knowing that post-install I'd be able to use netplwiz to untick the box 'Users must enter a username and password to use this computer' to bypass the login screen going forward. Imagine my surprise when I discovered the option was missing, even though the netplwiz hidden Control Panel was otherwise identical to older Windows installations. Where has it gone? **—Ivars Akmenkalns**

Memtest86 doesn't beat around the bush if it detects corrupt RAM.

THE DOCTOR RESPONDS: Believe it or not, the option's absence is by design. Later versions of Windows 10 introduced Windows Hello, which offers a range of password-less sign-in options, including PIN, plus facial and fingerprint recognition. When you choose one of these features during the install process, Windows flicks the 'Require Windows Hello sign-in for Microsoft accounts' switch to On, which results in the option being removed.

The good news is that you can restore the option without disabling Windows Hello. Simply navigate to 'Settings → Accounts → Sign-in options' and flick the switch to off. When you next open netplwiz, the option should be available again.

If it's still missing, open Registry Editor and navigate to HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\PasswordLess\Device, then change the DevicePassword LessBuildVersion value to 0. Close Registry Editor and reboot—the option should have been restored.

Boot Camp upgrades

What options do the millions of Intel Mac users using Boot Camp to run Windows 10 have for upgrading to Windows 11? **—Morris Pomey**

THE DOCTOR RESPONDS: The answer is, sadly, to look elsewhere. With its switch to M1 chips, Apple has phased out support for Boot Camp entirely as M1 Macs can only run an ARM build of Windows 11. Currently, this is still in preview, so not officially supported. The problem with older Intel-based Macs is that while later models ship with processors with TPM 2.0, the Mac motherboard doesn't support it. With Windows 10 supported until 2025, and Apple moving away from Intel chips, it looks like official support for running Windows on the Mac is coming to an end.

Prior to its official release, websites such as Apple Insider (https://appleinsider.com/articles/21/06/25/intel-macs-cant-run-windows-11-without-this-workaround) revealed ways of hacking the Windows 10 ISO installer to bypass the TPM 2.0 check and make it possible to install Windows 11 through Boot Camp. But there's no guarantee the workaround will continue to work.

If you're looking to run Windows 11 on an Intel-based Mac to run specific apps, then the most realistic approach is to invest in Parallels Desktop ($79.99 standalone, $99.99 annual Pro subscription, see www.parallels.com). This virtualization software creates a 'virtual' TPM chip to meet the Windows 11 TPM 2.0 requirement. Performance isn't as fast as a native install, but it can be seamlessly integrated into your Mac environment. And when Microsoft releases the Windows 11 ARM build, it will work on M1 Macs too.

Drive storage query

It's time to replace the hard disk I use for extra backup. Due to over-provisioning, I have two choices. Should I use the WD Black dated 2013 or the WD Blue dated 2020? Both are still in their original packaging and have the same capacity. **—Pete Reque**

THE DOCTOR RESPONDS: The Doc would not recommend storing a hard drive for eight years unused. Hard drives have a finite shelf life, depending on how they're stored and how often the data is accessed on them. Once a drive is in use, it's considered good practice to power it up at least once every five years to make sure its moving parts are in working order, and that the data on the drive isn't subject to magnetic field decay (the field is refreshed by reading and writing data to the drive).

The longer a drive is left unused or unopened, the greater the risk it won't work. That said, there are plenty of reports of people firing up PCs that have lain unused for ten years or more with no apparent ill-effects. Perhaps given your over-provisioning you could use the opportunity to use both drives: the newer one to replace your extra backup, and then test the older drive by using it for a few months as a fail-safe backup for the newer drive. If you're able to verify that it's still working after 3-6 months, you can then decide whether you can trust it on its own merits.

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GEAR of the YEAR

IT FEELS LIKE only yesterday we were gearing up for last year's Gear of the Year awards. That prestigious moment where we gather our thoughts on the very best hardware that has been launched in the last year (or at least the gear we've had the opportunity to test) and give you our picks for where you should invest your money. It has certainly been an interesting year, that's for sure, and jam-packed with a ton of new releases.

Last time around, we were still reeling from the first year of the pandemic, the world of computing had just arrived at a rather abrupt silicon shortage, and Nvidia had just launched its latest and greatest 3000-series GPUs as well. Life was, fair to say, a little odd. And, arguably, it still is.

However, a lot has changed since then. Most notably, we've had to rework our list this time around. Over the past 11 issues, not a single graphics card has scored higher than an 8. With the prices sky-high and supply still at an all-time low, we couldn't justify including any from either Nvidia or AMD this time.

As always, there's a lot of kit out there and companies that we haven't included this time around. That's not to say that they haven't produced some exceptional products, just that, well, we only have limited space in this old magazine of ours and, sadly, some parts just didn't make the cut.

So, with that out of the way, let's get stuck into our favorite gear of the year, shall we? –THE MAXIMUM PC TEAM

SPECIAL MENTION

OCULUS QUEST 2

VR has had a bit of a bumpy ride since its conception, but Oculus seems to be starting to get all the pieces just right, especially with its latest headset, the Quest 2.

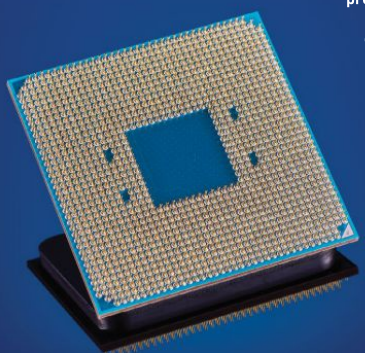
This $300 budget VR headset packs in a ton of tech, including refresh rates up to 120Hz, a resolution of 1832x1920 per eye, WiFi 6 connectivity (including complete wireless connectivity with your PC), some impressive controllers, 64GB of storage, 6GB of memory, a Qualcomm Snapdragon XR2 CPU, and it also manages an incredible three-hour battery life.

Easy to set up and easy to configure, if you're thinking about trying out VR for the first time, there's no better place to start than with the Quest 2. The only downside? Well, you need a Facebook account to use it.

- **$300, www.oculus.com**
- ***Reviewed: Maximum PC, July 2021***

CPU WINNER

AMD RYZEN 7 5700G



Another year rolls around, and AMD is still the absolute king of the hill when it comes to processor releases. This time though, it's not the debut of its 5000-series chips, but the much-awaited 5000-series APUs instead. Yep, the 5700G is the perfect high-end processor for those only after an integrated experience.

With strong single-core performance, exceptional integrated graphics prowess for older titles and esports, and an affordable $360 price tag, it's a chip that really does stand out from the pack. Even better, compared to the 3000-series APUs the 5700G has a full complement of PCIe 3.0 lanes too, so if you do want to add a discrete GPU later down the line, you won't be punished for it.

The only downside is that there's no PCIe 4.0 support, so you'll be missing out on those super high-speed PCIe drive transfer speeds. That's a small price to pay if you need an iGPU baked-in like this.

- $360, www.amd.com
- *Reviewed: Maximum PC, November 2021*

CPU RUNNER UP

INTEL CORE I5-11600K

Unlike last year, Intel has finally made it back into our good graces with its latest 11th gen series. Well, not all of those chips, but one in particular has made a comeback, and that's the legendary Core i5-11600K.

This six-core, 12-thread processor packs in excellent single-core performance, strong multi-core prowess, a tolerable iGPU, PCIe 4.0 as standard, and pretty decent thermal and power requirements too.

Early doors saw some poor PCIe 4.0 performance, but that was subsequently BIOS-patched out of the way. Although its price point is impressive, it does have one major drawback—no stock cooler as standard. But apart from that, if you're looking for a gaming processor, and don't fancy flocking over to Team Red, this chip could be the perfect choice.

- $262, www.intel.com
- *Reviewed: Maximum PC, June 2021*

SSD WINNER

SABRENT ROCKET 4 PLUS 2TB M.2 PCIE 4.0 SSD

There have been a few significant step changes over the years when it comes to storage speeds. The first was the move to SATA hard drives, the second was the introduction of the humble SSD, the third was the introduction of PCIe 3.0 drives, and lastly, of course, the move to 4.0.

On first pass-though, those 4.0 drives of yore were somewhat underwhelming. Although faster than their predecessors, it certainly wasn't enough to saturate the bandwidth.

That's something Sabrent corrected with its second-generation Rocket 4 Plus. The 2TB version we tested packed in some of the highest numbers we've ever seen (and even since), with sequential write speeds topping out at 6,836 MB/s, that's 1,700 MB/s faster than Samsung's legendary 980 Pro. Just an awesome drive, and well worth it if you can get a hold of one for your next productivity rig.

- $400, www.sabrent.com
- *Reviewed: Maximum PC, March 2021*

SSD RUNNER UP

SK HYNIX GOLD P31 1TB

For those of us not yet on the heady heights of a PCIe 4.0 system, this pick might just fix that storage itch of yours. Yep, it's a particularly juicy M.2 SSD from SK Hynix. The Gold P31 1TB comes in at a reasonable budget price of $135 but packs some impressive figures.

Not only does it top out the sequentials for the specification, but its random 4K read and write speeds also come exceedingly close to the likes of the Samsung 980 Pro, with a difference of less than 10 percent in some cases.

A smart pairing of TLC and SLC NAND flash, combined with 1GB of DDR4, really breaks the mold with this thing and allows it to hit those performance figures where it absolutely matters. SK Hynix has also included a five-year warranty and rates this SSD capable of enduring up to 750TBW over its lifetime too. Neat!

- $135, www.skhynix.com
- *Reviewed: Maximum PC, September 2021*

CASE WINNER

LIAN LI PC-O11-DYNAMIC

It's a case that we've ribbed no end in the mag, lambasting just how common it is and how many liquid-cooled builds are out there using this chassis. But, without a doubt, it's still the best case out there today. There's a reason why it has won all those awards, and why it's winning this one from us.

The PC-O11-Dynamic looks incredible, is built from some epic materials (mostly aluminum), has a fantastic array of layout features, extensive cooling support, hard drive support, and on top of that, is ridiculously affordable at $160.

The only downsides—though they are pretty minor—are that it is a bit bulky and could use a few more storage options for the true full-tower purists. But full marks Lian Li, keep up the good work.

- $160, www.lian-li.com
- *Reviewed: Maximum PC, June 2021*

CASE RUNNER UP

CORSAIR 7000D AIRFLOW

Corsair's 7000D chassis is a true monster when it comes to full-towers. This thing is designed with absolute cooling in mind and packs in support for two 480mm and one 420mm radiators at the same time.

If this thing was kitted out to the max on a water-cooled agenda, it could support no less than 24 separate fans. There's also support for motherboards all the way up to E-ATX, the potential to install ten 2.5-inch drives (or six 3.5-inch drives), and it features Corsair's new design—all clean-cut lines and solid materials too. It's a true monster.

The only downsides are that it is seriously big and weighs 41.2lbs straight out of the box. On top of that, sadly, there's no support for the 5.25-inch drive bays found in some of its competitors either.

- $260, www.corsair.com
- *Reviewed: Maximum PC, September 2021*

MONITOR WINNER

MSI MPG ARTYMIS 343CQR

MSI is a fairly new name in the world of monitors, making this victory all the more impressive. The MPG Artymis 343CQR is a feat of engineering brilliance.

With an impeccable 1000R curve radius, the VA panel pumps out an impressive 165Hz of punchy goodness. A traditional 3440x1440 resolution treats you to a neat 109ppi density. Combined with its exceptional HDR performance, and some impressive latency and response rates, those ghosting and other VA typical bugs are a thing of the past.

This king of ultrawide screens puts some of its pricier rivals to shame. It's not quite a budget item, though, costing just shy of $900.

- $900, www.msi.com
- *Reviewed: Maximum PC, June 2021*

MONITOR RUNNER UP

LG ULTRAGEAR ERGO 27GN880-B

In a slight twist on the usual monitor take, our second favorite screen of the past year is none other than LG's UltraGear Ergo 27GN880-B.

This neat little panel sits on top of a stand, meaning you have to clamp it to your desk. However, disposing of the usual stand arrangement has given LG the opportunity to include a more versatile mounting solution, with greater pitch and angles possible.

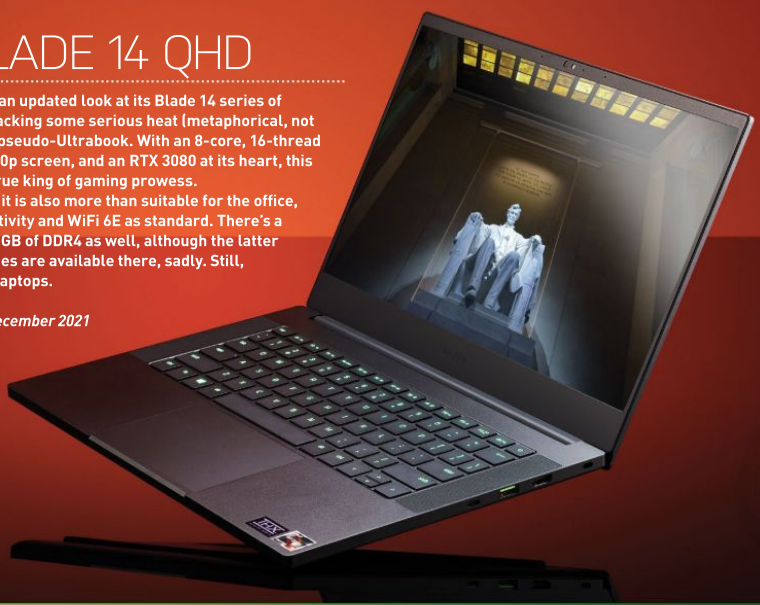
This Nano IPS screen is aimed at color artists and professionals, thanks to its impressive color accuracy and 98 percent DCI-P3 coverage. It is equally capable of gaming as well, with an impressive 144Hz refresh rate, 1ms G2G response, and FreeSync and G-Sync support as standard.

The only downsides, particularly for the creative worker, are a lack of USB-C connectivity and limited color space presets.

- $397, www.lg.com
- *Reviewed: Maximum PC, September 2021*

LAPTOPS WINNER

RAZER BLADE 14 QHD



Razer is back this year with an updated look at its Blade 14 series of laptops and, this time, it's packing some serious heat (metaphorical, not literal) into this super slick pseudo-Ultrabook. With an 8-core, 16-thread Ryzen processor, 165Hz 1440p screen, and an RTX 3080 at its heart, this super-sleek notebook is a true king of gaming prowess.

While it looks incredible, it is also more than suitable for the office, with some excellent connectivity and WiFi 6E as standard. There's a 1TB PCIe 3.0 M.2 SSD and 16GB of DDR4 as well, although the latter is soldered on, so no upgrades are available there, sadly. Still, this thing is just the king of laptops.

- $2,800, www.razer.com
- *Reviewed: Maximum PC, December 2021*

LAPTOP RUNNER UP

LG GRAM 17

Second in line for the throne this year is the LG Gram 17. In contrast to the monster above, this Ultrabook is solely aimed at the student or professional in need of a bigger screen and a lighter device—and, boy, do you get that. Weighing in at an incredible 2.98lb, this 17-inch notebook packs in an Intel Core i7-1165G7 quad-core processor, 16GB of DDR4, and 1TB of M.2 PCIe 3.0 SSD.

The screen is awesome too, with a color-accurate IPS panel and a resolution of 2560x1600, giving you a pixel density of 177.58ppi. There's a ton of connectivity included as standard, as well as support for WiFi 6 and Bluetooth too. It does fall on the pricier side, coming in a few dollars shy of $1,800, but the specs list alone makes it worth it.

- $1,796, www.lg.com
- *Reviewed: Maximum PC, June 2021*

SYSTEM WINNER

CORSAIR ONE A200

Another year and another Corsair One clinches the only spot on our system list for Gear of the Year. The A200 is an updated variant on this now prodigal lineup and features some of the latest and greatest hardware, including an RTX 3080, AMD Ryzen 9 5900X, 32GB of DDR4, and 3TB of storage too (1TB M.2 PCIe 3.0 SSD, 2TB HDD).

Originally developed as a single fan, convection design chassis, there have been some additional fans installed (notably for GPU chipsets), but apart from that, the cooling and noise potency of this thing is just awesome.

There's one caveat to all this though, and that's the price. Even in a GPU-starved world, splashing out $3,800 for a super-small ITX PC seems, well, excessive.

- $3,800, www.corsair.com
- *Reviewed: Maximum PC, July 2021*

HEADSET WINNER

CORSAIR VIRTUOSO RGB WIRELESS XT

Another win for Corsair with its Virtuoso RGB Wireless XT headset, which is, without a doubt, the best gaming headset around. With impressive neodymium dynamic drivers packing in a frequency response of 20-40,000Hz, with a sensitivity clocking in a -42dBV, and aptX Bluetooth and Dolby Atmos support, the noise produced by these crisp cans is second to none in the industry, at least as so far as we've seen at this price point anyway.

Wireless by design, the XT also supports a myriad of other standards and can be wired up using an analog 3.5mm cable, connected via USB-A, USB-C, or through Bluetooth, as well as the slipstream 2.4GHz dongle too. Battery life clocks in at a mighty 15 hours, or longer if you run it without RGB. It also packs in a removable mic, so when you aren't gaming it acts as a pair of pretty neat lifestyle headphones.

- $270, www.corsair.com
- *Reviewed: Maximum PC, September 2021*

MOUSE WINNER

HYPERX PULSEFIRE HASTE

Mice have been fairly light on the ground for us this year, but that's not to say there haven't been any standouts. Between the Corsair Sabre RGB Pro Champion, the Marsback from the previous issue, or the HyperX Pulsefire, there could only be one winner—and that's the Pulsefire Haste, of course.

This FPS-oriented mouse comes in at a lightweight 2.1oz (60g), and packs in an incredible sensor too, in the form of the PixArt PAW3335. Those holes might put off trypophobes, but they do keep your palms sweat-free.

Capable of tracking up to 16,000 CPI accurately, with speed figures of 450 IPS and 40Gs of acceleration, it's an awesome symmetrical mouse, ideal for palm and fingertip grips. It's reasonably priced too, at just $50.

- **$50, www.hyperx.com**
- ***Reviewed: Maximum PC, November 2021***

KEYBOARD WINNER

HYPERX ALLOY ORIGINS

TKL keyboard designs are all the rage these days. Some are good, some bad, but if you're looking for a new board for your fingers, there's no doubt that these ones should have your attention.

Although you do lose some of the functionality found in more full-sized solutions, TKL designs are considerably better for your ergonomic long-term form. Of all the boards we've tested this year, the standout by far is HyperX's Alloy Origins.

This affordable, red-switched, TKL packs in some incredible build quality, strong switches, and impressive software support. The only drawback is the lack of a clicky version.

- **$100, www.hyperx.com**
- ***Reviewed: Maximum PC, November 2021***

JUST HOW DO YOU BECOME A PC MODDER?

Kris Butterill gives us his personal take on how to get started PC modding.

PC MODDING IS at the absolute top of our custom computing hobby. It sits among the giants that make this community so great and continues to push through advancements and product tweaks into the industry itself. Vertical GPU mounts? Modders did that first. ITX liquid-cooled cases? Modders did it. Liquid-cooling in General? Modders did it (with household plumbing parts, would you believe?).

But there's more to it than that. It's an intricate art form, a way of showing off your personality and building something unique to you. The hardware might be obsolete in a few years from now, but ask any of those modders what build they're most proud of, and it'll bring back a flood of memories from yesteryear, now outdated by the superior chips of today.

For the extreme enthusiast, a PC is akin to a custom car. Unique, special, filled with memories of good times and more. Since its conception, the modding scene has grown into a behemoth compared to what it once was, filled with competitions and extreme professionals, and all sorts of amateur enthusiasts. It pits the best ideas against one another, with a ton of free hardware on the side, sponsorship, travel, and more.

So then, you want to start modding, going to events, showing off your latest builds on global social media channels, and work with the best hardware manufacturers in the world? Well, so did I back in 2019, and I didn't have a clue where to start.

My interest in building computers was with me way before I even thought about pursuing it in a more formal fashion. I mean, there's no training course you can enroll in and no books to guide you. It's been a different journey for every single person who has ever become a relatively well-known modder. It takes a lot of hard work and, at some point, luck may step in and help you along the way as well.

Today though, let's start with the basics, go over how to get started and hopefully, by the end of reading this, you might have a clearer idea of how you can get involved in the modding scene too.

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intel

GETTING TO KNOW YOURSELF

My life is average; I'm married and have two children, a mortgage, and all the responsibilities that come with everyday life. There are bills to pay every month, activities and days out to go on with the family, and the small matter of working 48 hours a week. I've always been handy, capable, inquisitive and functional, in terms of having a hands-on approach to learning. It's how I do things, take something apart, put it back together, rinse and repeat. It's why I started out as a mechanic for Volvo, moving on to Audi, and Buick before following in the family footsteps and joining the Fire Service at 23.

What I am getting at here is there's already a lot of commitment in life, commitments that come first, before even starting to look at taking on a modding career. The first thing you need to know is that modding takes three things; time, commitment, and perseverance.

Once you are prepared to give all those three things in equal measure, it's time to have a chat with yourself and be honest. Are you competent in building a standard DIY PC? I'm talking about simply fitting components to a case, adding an AIO and the mother of all tasks, the number one, and most asked question I ever see, where do these wires go? It's fine wanting to become a modder, and we all have to start somewhere, but if at this first step you are unsure, this is where you need to start reading, following tutorials, and getting hands-on, even with the most basic projects to learn the trade.

It's all about building from a foundation, being comfortable and competent. At this stage, some might even find that it's more involved than they first expected, the time commitment can't be met, and so on. It's better to know now that it's not for you, rather than six months down the line when you could potentially have invested both precious time and finances into the field. If this isn't for you, then that's fine, but if the above doesn't faze you then read on.

We'll assume you can build a standard PC, install Windows and download the latest drivers. So, now it's time to get involved.

From here, things start to get more complicated. Now you need to look at why you want to venture into the modding scene. Is it because you enjoy building PCs, want to show off your work to others, have some great ideas and a creative mind? There are a thousand reasons I can think of, but probably another thousand credible ones too. Once you have a reason, you need a plan, a direction, a road map, or whatever you want to call it.

Think of this stage like a job interview; ask yourself why you want to do this, and where you see yourself in five years' time. For some, it simply is the love of building PCs, others use it as a stepping stone to bigger and better things. Some may have a background in one particular specialist area, be it overclocking, great at taking photos, have access to all the machinery needed to create custom distro plates or props. Think about what you are good at, and what you can bring to the scene, and use that to your advantage.

BEING PREPARED

What do you actually need to start producing epic mods? This can vary from a couple of rattle cans to a vinyl cutter, tools, consumables, and, of course, hardware. There is little chance of being sponsored without a history, so you need to be clear in your mind that things won't fall into place straight away.

Depending on your background, you might already have a nice complement of tools at your disposal, use this to your advantage. A modder needs tools, it doesn't have to be a workshop full of the latest machinery, and modding can be as simple as having a jigsaw and a file to hand. It's better to start with hand tools, refine your craft to a point and then, when things start getting too complex or require such precision that it can no longer be achievable by hand, expand your equipment gradually.

In terms of more advanced tools, here's a couple of suggestions that might be worth considering:

DREMEL A modder's favorite that has so many uses. A beginner set is cheap and perfect for those delicate operations, and also helps to get into small spaces within a case for mods, cutting panels, trimming edges, and much more. Don't leave home without one.

A 3D printer could be the most useful item in your tool kit, but don't forget to get a Dremel too.

VINYL CUTTER Relatively inexpensive and can transform even the blandest case into something special. Most vinyl cutters can be found relatively cheaply with small ongoing costs for consumables.

Vinyl cutters can be used for a number of things, adding graphics and small details, but they can also cut stencils for using to add your airbrush designs to cases and parts. Stencils are also needed for glass etching, another way of adding a custom touch with relatively little consumable cost.

3D PRINTERS Probably the best thing in my tool kit, and one of the most fun things I have ever used. I did have a CNC, but the 3D Printer can do so much more. In terms of cost, a 3D Printer is also more accessible.

Some of my recent projects needed adapters for mounting Alphacool reservoirs to a case, and I also had four Corsair Commander Pros to fit too, cue some measurements, Sketch Up, and three hours later, I had all the parts I needed. It's great for prototyping, and I'm finding that I am using it for things even I didn't think it would be useful for. Its best quality, though? It saves precious time so that you can concentrate on other issues.

There are some epic case mods using 3D printed parts, and even fully 3D printed cases out there, the only limit is your imagination.

© DREMEL.COM

Down the line, if things go well, this should probably be high on your shopping list.

INSPIRATION

If it's just another Lian Li O11 Dynamic build with ten fans and an AIO, then I have some news for you, there are thousands of people doing that already. That's where you need to read between the lines, find that extra something that at first glance makes your work stand out from every other system.

Looking at what is already out there is a great point of research, one that sometimes gets overlooked. Trawl through the various forums and social media to see what the current trend is (pcpartpicker is a great place to start, along with builds.gg), what's emerging, and what no one else is doing. If people are not building what you have in mind, that could be for a couple of reasons; it isn't viable and the end result will be poor, or it could be that no one has thought about doing it yet. That's where you take the limelight and potentially set the next big trend.

For example, if you are a carpenter by trade, your experience working with wood can lead to concepts and ideas that someone without such knowledge will overlook. Metalworkers might view industrial themes and ideas for builds more favorably because it's an area they know in-depth. Whatever your passion, whether it's cars, sports, films, games, brands, there's something for everyone.

Transfer elements over to PC building and do something new, original, maybe exotic. There is inspiration all around us, every day, in every walk of life. Don't be scared to try something new. At first, it might feel absurd, but the reward generally outweighs the risk of trying something new. If you have the hardware to hand, especially when it comes to water cooling, then why not use two reservoirs, three, or even four? From a performance aspect, there's a diminishing return, naturally, but aesthetically, depending on the plan, it can make or break a build.

I remember placing a small Alphacool reservoir mid loop, above a GPU and thinking, nope, but once the loop filled up, it looked great, and so was the feedback (and actually the reason Zak hired me). The question I was asked most was 'Why?' My answer was why not? It's different, it fits the boldness of the build and it looked fantastic.

Modding is part trial-and-error. When it works, it just works.

BUILDING SYSTEMS

This right here is what it's all about. Modding PCs doesn't have to use the latest and greatest parts. Depending on your circumstances, you can start with older hardware. This makes it less expensive should you make a mistake and there's less pressure too. Be creative, even if it means cutting up a $30 case, it's not the end of the world if it doesn't turn out as expected. Sometimes the most effective mods involve the simplest of ideas.

There's an assumption that modders have access to all the hardware they could ever dream of, and while that's true for a small minority, for most it's a little more limited. I've built a number of totally different-looking systems that recycle the same hardware, essentially building one system and then stripping it down as soon as the project has been completed, ready for the next one.

Start small, if you already have a PC, use this as your first project. Look at what you have and what potential it has in terms of modifications. Some cases are so modder-friendly that some simple alterations immediately make them stand out. The local second hand

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market is rife with slightly older parts, cases, fans and a whole load of components can be found for little to no outlay on places such as eBay. Some subtle upgrades and even investing in extra hardware will help you build up a stock of parts. One of the biggest issues I had at the beginning, and still have now, is trying to keep a system dedicated for my own use, for office tasks, editing photos, rendering videos, and everything else that goes with modding.

All builds start with a plan and this can be based on a number of factors, if there is a new case coming out that fits perfectly with a theme, that will to some extent dictate the hardware. If there's an ATX motherboard you want to use, that will be the total opposite, dictating what cases are available. Scratch builds, desk builds, monster towers, they all start with a plan, maybe even a few sketches and then, a whole load of planning. What matters most, more than anything, is your attention to detail. There are so many aspects to building a PC, but the two areas that tend to be scrutinized more than anything else are custom hard-line loops and custom cables.

Custom hard-line loops take things that extra step, away from a bolt-on AIO and where things can truly start to get creative. As you build more and more systems, you get much more confident with the process and start to see things that you wouldn't normally. Bulkhead fittings to hide pumps out of sight, interesting tube runs, dual loops, coils, there are so many creative options that bending hard-line tubes brings. I won't lie, it takes time to perfect, something I am still doing. Be prepared to bend four runs to get the perfect one. There's a lot of waste to begin with, but experience will soon play its part as you get better.

Making custom cables is another aspect that, with relatively little cost, can make a build pop. Time and patience are key to producing either extensions or full replacement kits for your builds. Personally, I hate making my own

Use your photography skills to create a new look.

cable sets so I would sooner support someone in the community who does this on the side and produces results far better than I can. The thing is, not one single modder can do everything perfectly, everyone has a weakness, and realizing your own will help you. If it's not making cables, it will be something else, let the community help you, it helps them too, and by outsourcing small elements you can also help to build up relationships as well, which is vital in the industry.

BEING SOCIAL

Once you have a build under your belt it's time to share it with the world. Setting up on Social Media

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When showing off hardware, you can tag the manufacturer.

is one of the first steps to being noticed by the community and companies. If you decide to work under a modding name, then choose wisely from the beginning. You don't want to be changing things three years down the line because you wished you had picked something different. People get to know the names in the community, it builds familiarity and a following will start to form naturally.

There are a number of ways to start with social media, including Facebook, Instagram, Twitter, YouTube, Discord, forums such as Overclockers and Bit-Tech, and many manufacturers have their own dedicated forums. Setting up a website can help too, I use one to log the projects, features, and events I have been involved in, that way it can act as an online CV for anyone curious about your work.

If you are comfortable or have experience in front of the camera, then use that to your advantage and make YouTube your primary platform, if you have great camera skills and can make the final shots of a system really pop, then maybe Instagram and a Facebook page would be more suitable. Project logs can be very involved and in-depth, but whatever platform you choose, it's all about telling a story.

Regular posting and planning will help. You don't want to be posting once a month, it needs to be as regular as you can. If you are using a case from say, Cooler Master, for example, then let them know, tag the companies whose parts you will be using, and let them start to see what you are building.

Remember when I talked about custom cables and building relationships? Well, this is where it starts to all tie in together and help you along the way. If you post a picture and someone has made the cables for you, tag them, they will see it and hopefully repost it, tagging you in the process. You potentially just doubled your audience in a simple tag, they want to show off their work too so it's a great way to do things.

Many forums run monthly competitions, builds.gg and Bit-Tech to name just a couple, get those project logs going, you will gain valuable experience with each one and enter Mod of the Month events if you can. It doesn't matter if you place last, it's part of the process to learn from and build upon. I've built systems that I thought would place high but didn't. For whatever reason, people have their own preferences on what looks awesome and other systems in the competition, at that particular time will dictate, to some extent, how well your build is rated.

Don't let it get you down though, it's not because it's a bad build, it's just that other systems might have something that people favor more.

A build for ASUS to celebrate Ghostbusters at EGX 2019.

© MOD83.COM

Showing your work to the world in person is a great way to not only get people interested in what you are doing but may also bring a number of other perks. If it's a local meet or event, take your build, take some photos, tag the event organizers on social media, let visitors take pictures of it, ask them to share it on social media, even make a small placard with your details on it so people can find you.

Get involved and answer the questions they might ask, why did you do this, how did you do that. There are some huge expos and events around the world where your work can be shown, the plus side too is that at the bigger events, there are reps from many of the manufacturers. Play to their strengths, build using their hardware, and make sure they see your work in person.

MAKING CONTACT / SPONSORSHIPS

There comes a point when you have a number of builds under your belt, you have entered the forum events, posted to social media, and done as much as you can. Now do it some more. Spend another year refining everything you have learned, Three years in and I'm still learning.

At some point though, you will feel the need to reach out. You have started building that portfolio and following. You have used all the components you have and recycled them time and time again for another build. Sometimes it feels like you are getting nowhere and you need that next kick. Find out what's missing, do it some more and then do it again. Now, you either need to invest in more hardware or see if anyone is willing to help.

Straight off, the big hardware players might not be interested; you're unlikely to have a CPU, motherboard, and graphics card sent to your door unless you are really lucky or time it just right. Start smaller, the less expensive the items, the less risk there is to the company looking to sponsor. It's time to start making connections, finding the right people, and putting your ideas over to them. Build a system, see what you are missing, and maybe start with case fans, power supplies, air coolers, and AIOs. These are components you can easily show off, giving a sponsor a return on its investment

Now, finding the right people to contact can be a challenge in itself. Research their websites and social media, if you can't find what you are looking for, it's worth messaging the social media accounts of the people you want to work with, ask them politely if there's an email for sponsorships for your region. Some might reply, some won't. Don't pester them; follow the leads you have at this time. Once you have a contact, it's time to write them an email. Can I have free stuff, please? No, never write that. Even as a relative newbie, I get this now. It's strange, I'm not a manufacturer so it shows just how little research that some people are doing.

In your email, introduce yourself, attach images of your past work, maybe tell them you won a Mod of the Month, or show them how many views you had. Show them what you are working on and how their support will help set it apart. It's a two-way street, so show how you can provide exposure for them. Make sure you outline exactly what you intend to do so there's no doubt what they are getting in return. Proofread it once, then again, and when ready, hit that send button.

Now, wait. Give it time for the email to reach the intended recipient, allow two weeks, and then, if you have to, follow it up with a courtesy email. Some will have ignored the first, the second will most likely prompt a response of "Thanks for your email, sadly at this time we are not taking on new sponsorship requests". If they are interested, a response will usually be fairly timely. Respond gratefully, addressing any queries honestly and clearly. When you land that first sponsor, it's a great feeling, but if you keep up the hard work, it's the start of things to come.

A commissioned build for MSI and a Minecraft influencer.

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DELIVERING ON WHAT YOU PROMISE

Modding can be hard and, at times, the pressure is relentless. So you put the idea to the manufacturer, they loved it and want to support the build. The free stuff is on its way and then, for whatever reason, life gets in the way, you lose heart in the project. Whatever the issue is, you have to deliver. Remember these companies get literally thousands of emails a day asking the same questions and proposing the same things. They picked you, put their faith in your abilities, and now the responsibility lies on your shoulders to deliver.

Getting that first sponsor is as important as the sixth, tenth, or however many it ends up being, so build that relationship and keep it up. They are investing in you, both financially through the costs to them for the parts and shipping and also on a moral footing.

If there's a delay, an unseen issue, let them know as soon as possible what the issue is, how it can be rectified and when it will be resolved. Communication is key and the more you deliver on what you promise, the more chance there is that the relationship will continue. Why not go one step further and support them as much as they are supporting you? A $150 case from a manufacturer worth millions might not seem like a big deal, but multiply that across all the other avenues manufacturers explore, modders, tech journo reviews, events, giveaways, it all adds up, more often, to more than you might think in terms of outlay.

Start with components that you can easily show off

GOOD LUCK

So there you have it, how to start in the world of being a modder. While this isn't all, it's enough to get you on the right track, and to some extent, it's how I started too. I've had my share of luck, but that was backed up by a lot of hard work and it's because of that I'm writing this article. Modding has taken me on a great journey so far and it has opened up some fantastic opportunities. I never expected to be writing for a magazine, let alone giving advice on modding.

I have one final piece of advice. Enjoy it. Once the fun dissipates and it becomes a chore, it's time for a break, no matter how good you are or how many builds you have lined up. Come back fresh-faced when the time is right, your work will reflect the results of taking a breather. So now, go my little budding builders, cut up that case, mount that radiator where you want to, go with the rainbow RGB, hell, go with no RGB if you like! It's your build, it's your rules. Don't follow trends, set new ones, and remember, if anyone asks "Why?" Simply reply, "Because I can".

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COMMISSIONS

For some, this is the pinnacle of modding. That email drops in from a global player, the one company you love more than any other, and they want you to build them a PC.

They have seen your work, your posts, and your sponsored builds, and now want you to create something special. Personally, I've been there, and it was only at this point that I finally felt I had made it, and could justify the time, commitment and perseverance. Heard that bit before? It makes more sense now than it did at the beginning, right?

I also asked, where do you want to be in five years' time? This is what I wanted to achieve and well, I made this in fewer than three, but mileage does vary and luck plays a massive part. I had a request to build a system for MSI; they were gifting a build to a well-known *Minecraft* influencer and wanted me to build them something, in exchange for some hardware, I could use for my own builds.

The client in question had over 8 million YouTube subscribers, so the pressure was on. Looking ahead, I could see that this build and potential exposure would help me again for the future, especially with the hardware they wanted to send out.

Roll on six months and there was an email from Intel, this time wanting to pay me to build them a system! They had seen the build I did for the influencer, two days after that I got another email, ASUS wanted me to build them a system too. All of a sudden, I was in demand.

For the next few months, all my personal work went on hold, I had to explain to my sponsors and again communication is key. These commissions were a priority, but that didn't mean I could negate my other responsibilities.

Luckily, they were pleased for me. It showed that the faith they put in me was paying off in the fact that these other brands now wanted to work with me, based on what they had seen from my work with sponsors. It all ties together, eventually, and it's all worthwhile.

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Hurricane Irma strikes Miami, Florida, in 2017. Could computer forecasting reduce the impact of storms?

PREDICTING THE UNPREDICTABLE

Ian Evenden investigates how supercomputers and machine learning are revolutionizing the science of predicting extreme weather events.

THE MAMBILA PEOPLE, who live across Cameroon and Nigeria in West Africa, like to watch the movements of crabs and spiders. As part of a practice called Nggam, a stick and a stone representing a binary choice are offered to the multi-legged creatures, along with some cards placed between them. This is all part of a plan to tell the future.

The wisdom-seekers leave the cards intact for up to 15 minutes, during which time the crab or spider may have come out of its hole and disturbed the cards, producing a pattern that can be interpreted. If particular cards have been moved toward the stick or the stone, then that choice is bound to become reality.

Elsewhere, some people still believe to this day that the position of the stars and planets at the time of their birth has an effect on their future. While in ancient Rome, a haruspex consulted the entrails of sacrificed animals to gain insight into what was about to happen.

In Victorian England, the Hermetic Order of the Golden Dawn played a four-player variant of chess in an attempt to predict future events, while the Ancient Greeks practiced dracomancy (predicting the future by way of dragons), though it's not clear where they found them.

Of course, another way to predict the future is to use computers.

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WEATHER FORECASTING

Knowing what the weather is going to do is often a case of simply looking out of the window, but being able to predict weather conditions several days in advance is another matter. Being able to predict the future is more useful than knowing whether you'll need a light jacket or waist-high rubber waders this afternoon.

But predicting the weather is a difficult science because there's a lot going on in our atmosphere. There's a lot of data to be processed from orbiting satellites, airplanes, ships at sea, land-based weather stations, and more. But weather forecasting had more humble origins.

It takes us back 170 years, to Vice-Admiral Robert Fitzroy, a celebrated sailor in the British Navy who had been on the second voyage of the HMS Beagle with Charles Darwin, would become governor of New Zealand, and a man who thought the weather ought to be predictable. It generally wasn't of course, and at the time was considered to be completely chaotic. Indeed, when the idea of forecasting the weather a mere 24 hours in advance was floated in the British Parliament in 1854, the whole place rocked with laughter.

In the 1800s, weather forecasting's cutting-edge technology was a frog. Having caught one, you kept the poor creature in a glass jar with a small ladder and some water at the bottom. The idea was that, if the weather was going to be fine, the frog would climb the ladder, and if it was going to rain it would languish at the bottom in the water. Changing this water every week or so was considered essential. Indeed, even today, meteorologists in Germany are sometimes called 'Wetterfrosch', or weather frogs.

IMPROVING ACCURACY

Of course, this was a rather hit and miss method of weather forecasting, but with the loss of the ship Royal Charter in bad weather in 1859, Fitzroy, who had set up a small office to worry about the weather five years earlier, was authorized to start issuing storm warnings, which he did with the aid of a new invention, the electronic telegraph. From his office in London, he gathered information from 15 coastal weather stations and, if he thought a storm was likely, would send a message to the nearest port, warning shipping.

A frog in a jar was the cutting edge of 1800s weather forecasting tech.

Above: **A portrait lithograph made by Herman John Schmidt of Vice-Admiral Robert Fitzroy, founder of the Met Office.**

Right: **Helen Roberts is a senior operational meteorologist at the Met Office, based in Exeter, UK.**

He developed weather charts known as 'forecasts'—a previously unknown word—and by 1861, was delivering these forecasts of the weather two days ahead, published in *The Times* newspaper.

Unfortunately, Fitzroy's forecasts weren't always accurate. "Yesterday, at two o'clock, we received by telegraph Admiral Fitzroy's signal of a southerly gale. The gallant meteorologist might have sent it by post, as the gale had commenced the day before and concluded fully 12 hours before the receipt of the warning," read a letter in the *Cork Examiner*.

However, the office he founded back in 1854 is still going today. It's known as the Met Office, has its headquarters near the city of Exeter in the south-west of England, on a street named Fitzroy Road, and is home to some of the most powerful supercomputers in the world

WEATHER & SUPERCOMPUTING

The Met Office's computing ability is, rather like the weather, in a state of change at the moment. The three Cray XC40 supercomputers it acquired in 2015 (14 petaflops of Haswell Xeons and Nvidia Tesla GPUs, for a total of 460,000 cores) are still the fastest machines in the world dedicated to weather prediction. They're a bit old, though, and have dropped off the Top 500 list of the fastest supercomputers worldwide, having once held 11th place. So, an upgrade is in order.

A multi-million-dollar deal was signed with Microsoft in April 2021, and the Met Office's new supercomputer will be twice as powerful as anything else in the UK. Each of its four quadrants could take its place among the top 25 machines worldwide. With over a million processor cores, six petabytes of memory, and the ability to store and process nearly four exabytes of data (10,000 years of HD video), it will be powered by 100 percent renewable energy and should be up and running by summer 2022.

Helen Roberts, a senior operational meteorologist at the Met Office, says: "It's a bit of a hybrid. Some of it will be on our premises and some of it won't be, plus we are making much more use of the cloud than we have done before. We'll be working with Microsoft for a decade or more on this, and when fully functional, it will be a big step up in our capabilities."

That sounds brilliant, but how do you forecast the weather with a supercomputer? "At the moment, our model uses the fundamental physical equations of the atmosphere," she explains. "Effectively what this does is split the atmosphere into three-dimensional boxes that go up through the depths of the atmosphere and right the way around the globe. It has a resolution of around 10 kilometers at the moment. Knowing what the atmosphere is doing now is a really key part of numerical weather prediction.

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The Met Office's three Cray XC40 supercomputers are to be replaced

Without that, we haven't got much hope of predicting what it's going to be doing in the future, so live observations are key.

"It's crucial for metrology to be part of the global community, and we do that through many routes, but one of the key ways is through the World Meteorological Organization. Based in Geneva, Switzerland, it's an apolitical community where all countries can contribute observations in order to help each other. The weather doesn't have any boundaries, and we really do need to know what's happening right the way around the globe to be able to use our models effectively."

Having gained a good starting point for the model from all the live observations coming in from around the world, the Met Office puts its Crays into action. "The physical equations are run at the grid box corners, and we run what we call 'ensembles', where we run the model more than once," says Roberts. "At the moment we use 12-member ensembles, where we slightly tweak the starting conditions. As brilliant as the observations we get are, we haven't got them from every single point across the entire globe, so slightly tweaking the starting conditions of the model will give us a different forecast."

"If all 12 in the ensemble are saying a similar thing, that gives us a high confidence in the forecast the model is predicting. If nine of them are giving one sort of solution and three are giving a different one, then there's uncertainty and we start to bring probabilities into play."

Which sounds a bit like *Minority Report*, only with more people in the swimming pool. Rather than just shooting those they disagree with, however, the Met Office has ways of dealing with split opinions: "When we get an answer, or a variety of answers, from the supercomputer, some of the data goes straight to our customers, and some is further processed using algorithms and machine learning," says Roberts. "Or it could be done by human meteorologists, and that is done regularly because our models aren't perfect, and until they are, it's really useful to have people in the loop to see how well the models are performing and to tweak them as and when required."

GLOBAL RESOLUTION

Being UK-based, the part of the computer model that sits over the British Isles uses smaller boxes for a higher resolution forecast in that area. Roberts looks forward to the delivery of the new supercomputer so that resolutions can be tightened elsewhere too, and more models can be run at the same time as part of an ensemble. "By increasing our supercomputing capability, we can increase the resolution of our global models and run them more frequently, which is beneficial. As you can imagine, ensembles take up a lot of processing power, so having more members in ensembles and being able to run more of them at a higher definition gives us more information and more accurate too."

This description makes it sound like there's one climate model to rule them all, but that's not the case. Even within the Met Office, they run different models together as part of the ensemble approach. "We have one type of model that's dedicated to the oceans, and one that's focused on the atmosphere," says Roberts. "Increasingly, what we're trying to do is to combine those models, and this is where increased computing power comes in. The ultimate would be a digital twin [of the Earth] where everything interacts with everything else because, as you can imagine, the atmosphere and predicting climate change is so incredibly complicated. There are feedback mechanisms that are difficult to model, and it's difficult to understand how they will play out. The interactions between things like nitrogen and the uptake of carbon into the land are a small example of mechanisms that we don't necessarily understand yet."

"Something our model has historically struggled with is cloud types. What we don't know fully yet is whether high clouds, such as cirrus clouds, will be more or less frequent in a warming climate, and that has big implications for how much of the Sun's radiation is reflected back, or reaches the Earth's surface. All these tiny interactions can have huge implications for what will actually happen to the climate, so the more we can link the different models together, the better."

NOAA

All the different models have their own strengths and weaknesses, and many other national weather services around

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the world have their own models with their own strengths and weaknesses. The National Oceanic and Atmospheric Administration (NOAA) part of the US Department of Commerce based at Silver Spring, Maryland, is also in the process of upgrading its computer systems. Two new 12-petaflop Crays will be moved into a facility in Virginia and operational by 2022. They join existing Cray and Dell systems to give the agency a capacity of 40 petaflops to direct into forecasting and research. This, combined with the Met Office and others worldwide, means huge amounts of processing power are being employed to tell us what the weather will do next. So we must be getting pretty accurate?

"As your computer becomes more powerful, your accuracy increases," says Roberts. "We tend to see an increase of about a day per decade in terms of forecast accuracy. It's tricky because it depends on what parameters you're looking at. One that we use quite often is the next day's temperature, and that's in the region of 95 percent accuracy for knowing tomorrow's maximum temperature."

The Met Office and Exeter University have partnered with Google to build an AI model capable of predicting whether it will rain up to 90 minutes beforehand. Google's involvement is through its DeepMind offshoot, the people whose AI trounced all-comers at a *StarCraft II* tournament in 2019. DeepMind's CEO and co-founder is Demis Hassabis, the designer of the *Theme Park* video game, a UK government adviser, PhD in cognitive neuroscience, pentamind champion at the Mind Sports Olympiad four years running, and yet still only 45 years old.

AI ASSISTANCE

DeepMind and the Met Office trained a generative adversarial network (GAN) to predict rain across a region measuring 1,536 x 1,280km (954 x 795 miles). To do this, it was shown three years' worth of radar data gathered at five-minute intervals and was asked to predict what would happen next. A panel of 50 meteorologists then ranked its predictions compared to those produced by more conventional means. The GAN was ranked first in terms of accuracy and usefulness 98 percent of the time.

"Rain showers and thunderstorms are tricky to predict exactly," says Roberts. "What our models do well is give a forecast of areas that are more likely or less likely to see them. A good analogy is boiling water. You know it's going to boil, but saying exactly where the bubbles are going to surface is difficult, and that's where artificial intelligence may come in."

An aerial view of the Carrizo plain, South California, with the San Andreas fault easily visible.

The project remains an interesting piece of research for now, however, and isn't being put into frontline forecasting.

EARTHQUAKES & SEISMOLOGY

Sometimes, however, a forecast becomes a real-world life-saver, as in the case of the earthquake early warning system spread across California, Oregon, and Washington, with Utah expected to be next to join the system. Known as Shakealert, it can identify and characterize an earthquake a few seconds after it begins—no mean feat in an area where the ground is constantly shifting.

Once an earthquake is identified and the system put into action, it relies on the laws of physics to alert people before the quake reaches them: as mobile phone signals fly at around the speed of light, which is much faster than the earthquake waves propagate through the Earth, people far enough away from the quake get enough warning to take cover, or shut down industrial equipment. Trains can stop, airplanes abort a landing if safe, or stop taxiing. Cars have time to get away from tunnels or bridges.

A large earthquake that occurs at the point fault lines running north-south in California take a quick diversion west and head out into the Pacific near the home of the Humboldt Redwoods in northern California, is felt in San Francisco a minute later, and Seattle four minutes after that. It's not a great deal of warning, but it can save lives. Unfortunately, there is always a region close to the quake where the cellphone alerts don't reach people quickly enough.

That said, earthquakes rarely come along, and while it's not possible to predict where a new one might go off until it's actually started, the aftershocks that follow it can be. "The bigger the earthquake, the more aftershocks it has, it's a well-known relationship," says Dr Morgan Page, a statistical seismologist at the US Geological Survey based in Pasadena, California.

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Dr Morgan Page is a statistical seismologist working at the US Geological Survey.

The Denali supercomputer at the USGS headquarters in Pasadena, California.

Future computers may predict storms, such as this one in Broken Bow, Nebraska in 2013.

"Aftershocks drop off over time," she continues, "so if there are 100 earthquakes the first day, there will be 50 earthquakes the second day, 30-something on the third day, it's a regular relationship. You can say the same about where they occur, most aftershocks occur close to their mainshock but peter out with distance.

"The thing we can't predict is the size of an earthquake, it's just basically random sizes. So, given an earthquake, there's about a five percent chance it's going to trigger something bigger than itself."

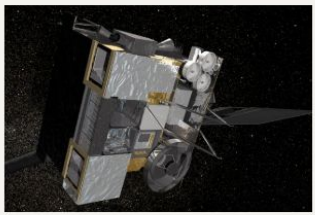
And just as with predicting the weather, there's lots of computer modeling going on, but in a way that you might not expect. "You put out this initial forecast based on 'an earthquake happened' or 'a big earthquake happened', then we look at past sequences in that region and similar tectonic regions worldwide," says Page.

"Once the sequence starts to progress, we can see if our model is predicting too many or too few aftershocks, and we can adjust it based on how many aftershocks are detected. As time progresses, we can get a better handle on how accurate the sequences are and we refine the model."

LAPTOP PREDICTIONS

Sounds like the USGS must have a pretty big supercomputer then? "We use Amazon Cloud for a lot of our forecasts," says Page. "Some are simple enough that we can run them on our own laptops. The kind of modeling we do is similar to the epidemiological modeling that's used for a disease like COVID. In the same way that one person can infect a number of people, and those people go on to infect others, and there's a cascade of contagion. Earthquakes are like that, in that one earthquake has aftershocks, and each of those has its own aftershocks, so you get another generation of aftershocks, and a cascade of earthquakes.

"The best models [for earthquakes] are more empirical than weather," Page continues. "You're really just basing it on things that have happened in the



WHERE ARE THE SATELLITES?

Much of the data for our weather forecasts comes from polar-orbiting satellites, those that orbit the Earth north-to-south and pass roughly over the poles. They are generally at low altitudes between 125 and 600 miles up, though more data comes from geostationary satellites 22,000 miles above the Earth, and yet more from deep-space satellites, such as the National Oceanic and Atmospheric Administration's Deep Space Climate Observatory that sits a million miles out.

A particular type of polar orbit, known as a sun-synchronous orbit, means the satellite passes points on the Earth's surface at the same time every day—for example passing over New York at noon each day. By taking pictures and measurements as the satellite passes over the same spot at the same time day after day, patterns of weather can be studied, and the conditions before dangerous events, such as floods or forest fires, can be identified so that they can be more easily predicted in future.

A geostationary satellite, being much farther away and not moving relative to the Earth's surface (a satellite in a 500-mile orbit travels at 4.5 miles per second) can take in a much broader view, often able to image an entire hemisphere of the Earth at once. These are often the images you see in TV weather broadcasts, with cloud cover imaged in visible light and the near infra-red, while infra-red imaging is used to see water vapor in the atmosphere, as well as the movements of ocean currents.

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EARTHQUAKE DEEPDIVE

In geologically active areas, the ground can move a lot without it becoming an earthquake. The trick of earthquake detection is to tell the difference between the earth shifting around a faultline, including tremors, and the destructive shaking that accompanies a quake.

During an earthquake, the rupturing fault sends out three different types of waves. P-waves come first, setting off earthquake detectors, but rarely causing significant damage. These travel faster than other seismic waves and can travel through solids and liquids—even gasses, but they are rarer underground. The P can stand for 'primary' or 'pressure' wave, as it's created by repeated compressions and decompressions. Their motion is in the same direction as the wave propagation.

S-waves come next, and these are the waves that cause the most damage. The S can mean 'secondary' or 'shear', and it's the shearing or side-to-side movement (their motion is perpendicular to wave propagation) that will knock down buildings.

Raleigh waves, triggered by the interactions of P and S waves at the surface, are slower still, but have a rolling motion similar to ocean waves, and can cause even more damage. Luckily, their amplitude decreases exponentially with the depth of the earthquake's hypocenter underground, so only strong, shallow quakes produce particularly destructive quantities.

Raleigh waves operate at a frequency that, though inaudible, can be detected by mammals, birds, insects, and spiders. This is an area of active study, but it's thought animals may receive an early warning of quakes through this system, which is used by elephants to communicate at great distances through infrasound, though this operates at a much higher frequency than the waves generated by earthquakes. Humans have nerve receptors in their joints, Pacinian corpuscles, that should be able to detect Raleigh waves, but people do not seem to consciously respond to the signals. It is not yet known why.

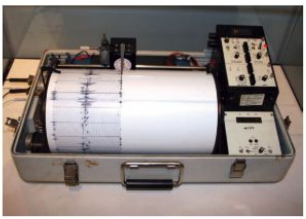
past, and running it forward. We have a model that runs for all in California and has all the faults in it. We tried to run the physics on the fault, but because we don't actually know the state of stress deep in the Earth, we're not running the current state forward in time, but running other versions of what history could be and then mining those catalogs for data. We don't yet have a good handle on how similar our six base models are to the actual Earth, they are more like guesses. Weather people can measure a lot more in the atmosphere than we can underground."

Indeed, while the Met Office can rely on a network of weather reporting stations on land and sea across the world, all within the atmosphere they're trying to study, the USGS has to make do with boreholes and surface seismometers—not ideal if you're looking for things happening an average of 12 miles below the surface in California, and over 350 miles down in parts of the Pacific near Japan.

"We're only seeing what's happening on the surface, boreholes aren't that deep," says Page. "We measure surface movement using GPS, and how quickly the Earth is moving, but it's just the surface extrapolating what's going on underground. We can figure out when and where an earthquake happens because we know the travel time of the waves. Similarly, when a big earthquake happens, we try to image it underground, based on our measurements on the surface. It's like having an MRI scan on your head with the sensors on the outside, and they manage to image what's going on in your brain.

"The model is only as good as our understanding of the Earth's structure, and how fast the waves are propagating underground. There are always uncertainties. The epidemiological-type models came from the epidemiological community, and in the 1980s were ported over to seismology. They're still the best models we have for predicting the rates of earthquakes, and we're still plugging away to incorporate more physics into these models. We're seeing hints of what lies beyond those simple models, another layer of predictability waiting to be seen."

Luckily, different places around the world can be studied to provide further insight, as some are more enthusiastic than others in terms of the number of aftershocks they produce. "There are different tectonic regions," says Page, "so there are places over continental crust, and there are places over oceanic crust, and there are subduction zones or one place that's affecting another, and all these places have different aftershocks. Some have depleted aftershocks and others have more energetic aftershock sequences. We try to get as much data as we can by finding earthquake sequences in similar regions so that we can get the best estimate of what's going to happen.



A kinemetric seismograph responds to movement by tracing on a roll of paper.

"Subduction zones [where cold ocean floor sinks back into the hot mantle of the Earth] are the most energetic, and the least energetic are transform boundaries, like the one in the middle of the Atlantic."

USGS & MACHINE LEARNING

The USGS also has some pretty interesting hardware. The first supercomputer available to all USGS staff was Yeti, a Cray with 1,456 Ivy Bridge cores and 2,272 Haswell cores, 5,120 Nvidia Quadro K2200 GPU cores, and 29,952 Tesla K80 GPU cores, plus 366 Xeon Phi cores. Yeti has 32,128GB of RAM and was benchmarked at 1,021 teraflops in 2019. Elsewhere, you'll find Tallgrass, a Cray Urika-CS prototype designed for AI and analytics. It features 792 CPU cores, 122,880 CUDA cores, and 15,360 Tensor cores for a total capacity of 236 teraflops. There's Denali, another Cray with 9,280 CPU cores and an estimated peak computational performance of 660 teraflops when it becomes operational in 2022.

Machine learning is starting to be used to tackle the huge amount of data the USGS seismometers produce. "It mines more earthquakes out of the catalogs than a human analyst could find," says Page. "A lot of it is template-matching, so it figures out there's one really small earthquake, a bunch of wiggles basically on the seismogram, and then it combs through years and years of continuous data looking for other little wiggles that more or less match that. And from that, it can find even smaller shapes that look like those wiggles. The better catalog we get, the more patterns we'll be able to figure out. If we can go from magnitude two to magnitude zero that's 100 times as many earthquakes, which is a big difference."

"From the data we have so far, it seems like big earthquakes and little earthquakes start off the same, so

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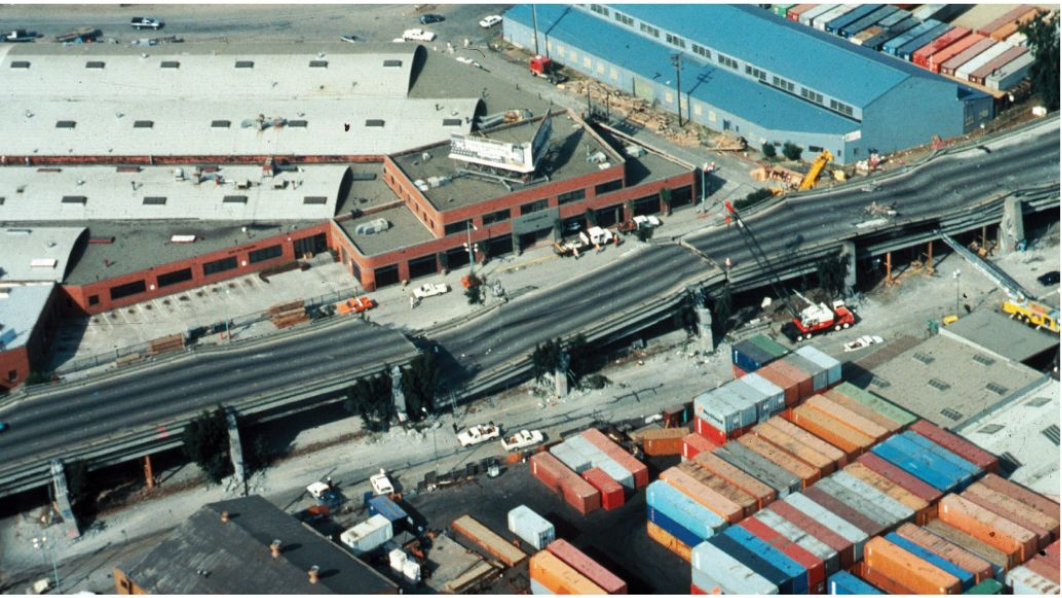

The 1989 San Francisco earthquake caused the Cypress Viaduct to collapse. Earthquakes are much more difficult to predict than the weather.

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without knowing the distribution strength deep underground, or to image it, we're not going to be able to predict how big it will be until it gets to that size."

And it's not just in Pasadena where the idea of turning machine learning loose on earthquake data has taken root. In 2018, a competition was launched in which entrants had to design their own AI to predict earthquakes being artificially generated in a laboratory. It was open to anyone, and thousands of people entered. The results, published in February this year in the Proceedings of the National Academy of Sciences [https://bit.ly/MPC-wobble], were remarkable. Some teams, none of them with any background in seismology, nearly got it right.

It's important to remember that this was an artificial situation, a synthetic benchmark if you like, but the competition not only yielded insights into seismic data but is also being used as a tool to further spread the good news about machine learning [ML] in geophysics. "The approach may provide a model for other competitions in geosciences or other domains of study to help engage the ML community on problems of significance," the organizers, a coalition of scientists from Los Alamos National Laboratory, Stanford University, and Google, wrote in the abstract to their PNAS paper.

There are definite signs the lab data can be applied to the real world. "ML has revealed the time remaining before an earthquake in the laboratory and particular types of tectonic earthquakes known as slow slip events can be anticipated from statistical characteristics extracted from seismic data," the organizers continued.

At first, nascent AIs were provided with huge amounts of data about the movements of an artificial fault—two steel blocks surrounding a lump of rock that are moved to simulate the strains of being squashed between two tectonic plates. If the rock cracked, then the whole assembly lurched, and that was considered an earthquake. Pretty soon, the machine learning models had identified a handful of energy signatures in the data that always preceded a crack.

This was considered too easy, so the team moved on to Kaggle, a platform for sharing ML research, and opened up their competition. Putting up a $50,000 prize for the top five teams, they announced they would be simulating earthquakes for six months in 2019, and invited all comers to predict them. To the ML community, this was too good an opportunity to overlook. Over 4,500 teams signed up, and the eventual top five became really good at quake prediction, despite some unorthodox approaches. One fed random noise back into the prediction model, which made it better. No one knows why.

The winning team, The Zoo, was made up of eight people across the US and Europe who had never met, and who had expertise in AI, mathematics, computer science, operations research, electrical engineering, insurance, hotel management, and credit risk. Anything but seismology. The Zoo never took first place in any of the competition's daily rankings but ranked consistently high enough to take the overall win. Hopes are high that the lab data will scale up to San Andreas level, but first, it needs to be tried out on relatively quiet faults to see if the ML models hold up out of the laboratory.

And it's not just earthquakes that this technology could learn to forecast. "There are a lot of earthquakes in volcanic regions," says Page. "And when volcanoes pick up, a lot of earthquakes start too." So in the future, we could be looking at a net of AIs monitoring the globe, looking out for severe weather, quakes, volcanic eruptions, and whatever else can be modeled from the enormous streams of data our sensors pour out day after day."

The science of prediction has come a long way from the invention of the weather forecast in the 1860s, but we probably could have predicted that it would.

CENTERFOLD

PERFORMANCE GEAR LAID BARE

Netgear RBKE960 Mesh Router System

1 10 GBPS

This setup comes with a 10Gb/s ethernet port for your WAN connectivity as standard, along with a 2.5Gbps LAN port on each router and satellite (you can use this 2.5Gbps port as a wired backhaul for the satellites too). For everything else, you also get three standard 1Gbps ports per device.

2 WIFI 6E

As mentioned, it comes with support for WiFi 6E via a quad-band solution. There are three bands used for your devices across 2.4, 5 and 6GHz, plus an additional "hidden" fourth 5GHz band that is dedicated to providing connectivity between the router and its satellites.

3 IOT NETWORKING

A dedicated smart devices network ensures that all of your interconnected thermostats, cameras, and doorbells sit on their own isolated network away from your PCs and data-sensitive systems.

LIKE IT OR NOT, our lives are now intertwined with wireless connectivity and access to the internet. Of course, that has come with its own downsides. Certain unscrupulous parties have sought to sow discord and false truths, benefitting from it in the process, and addiction to it can be rife in a lot of unhealthy ways.

But what we've gained, as a species, from the world wide web far outweighs the net negatives and the malicious actions of a small minority, in our opinion. Everything from knowledge, to the ability to communicate with family and friends across the globe, to being able to enjoy the latest and greatest content produced by the army of creatives that call this planet their home. The internet has been revolutionary for us as a society. Staying connected is paramount, and the humble router is a cornerstone of that process.

We have waxed lyrical about a lot of routers over the years in our *Centerfold* feature, but none of them have impressed us quite as much as Netgear's latest RBKE960 Mesh system. If future-proofing had a physical representation, it would be this.

The industry's first quad-band WiFi 6E mesh solution, the RBKE960 comes in at an eye-wateringly expensive price of $1,500 for the three-unit starter pack, with each additional satellite setting you back $600 alone. Even the single router plus one satellite configuration costs near enough $1200, and at first glance, it just utterly boggles the mind.

It's without a doubt, the most expensive router system we've ever looked at here at *Maximum PC*, but not without good reason. The RBKE960 is a device looking forward. It has been developed to include everything you could possibly want and need for at least the next ten years. From a technological standpoint, no holds have been barred in its design. –ZAK STOREY

© RAIMOND KLAVINS ON UNSPLASH

PHOTOGRAPHY AND THE EVOLUTION OF IMAGE MANIPULATION

FROM EDITS TO FORGERY, CAMERA TRICKERY TO 'PHOTOSHOPPING', *SAM LEWIS* DELVES INTO THE ART OF IMAGE MANIPULATION

IN A WORLD where photography is constantly at our fingertips, the thought of life without it seems pretty alien. It's fair to say that without the camera, history would look completely different and so many memories would have been lost forever.

Over the past decade, smartphones have replaced the camera as the most accessible and convenient choice of snapper for many people and while the days of the DSLR aren't yet numbered, that technology has changed the art of photography beyond recognition. As smartphone cameras have evolved, so has the ability to edit your images. As useful as photo manipulation is, the technology can be used for the wrong reasons—fraud, false advertisement, click-baiting, air-brushing, and the trend for 'deep fakes'.

But it can be beneficial too. Editing is essential to get the perfect image—simple brightness adjustments have saved many a photo from the bin. However, it wasn't always this way. Imagine waiting a couple of weeks for your holiday snaps to be developed, only for them to be too dark or overexposed. Photography and image editing have come a long way since then, so let's take a look at how this all came to be.

A SNAP FROM THE PAST

THINK IMAGE MANIPULATION today and Adobe's Photoshop software may spring to mind. In fact, so embedded in popular culture is this program that 'photoshopping' has even entered the lexicon. Image manipulation has been normalized to the extent that photoshop is more of a term to describe this technology than the application itself. But how did we get here? Adobe's giant plays a massive role in this whole industry, but it wasn't the start. Before getting familiar with where image manipulation came from, we need to understand what it truly means.

In short, image manipulation is the art of transforming an image to get a specific and desired look. Of course, it's not quite as simple as it sounds and there are plenty of implications to it. Since the creation of the first camera, photo editing has naturally developed alongside it.

It's interesting to note that image editing actually came before digital cameras themselves, way before in fact. Let's scroll all the way back to the 19th century and a Frenchman named Joseph Nicéphore Niépce, who in 1826, shocked everyone with the world's first photograph. Today's technology is evolving at such an alarming rate that we become immune to its effects, but imagine way back in 1826, what it meant to take a view and freeze it in time.

The start of photography emerged with the creation of the 'camera obscura' and this helped create the first photograph. Camera obscura is Latin for 'dark room' and surprisingly enough, it involved a dark room or box with a small lens or hole on one side, through which an image is projected onto a wall or surface. Using camera obscura on a photographic plate of pewter (malleable metal alloy), Joseph Nicéphore Niépce created an image of a view outside of his studio window. On the plate was a light-sensitive compound created by Niépce, and the image took eight hours in direct sunlight to develop.

He stumbled upon this method whilst trying to make it in the growing market of lithography. This printing technique involves engraving or etching into a wax-like, oily substance on a plate, then using a chemical process that repels the ink to transfer it onto paper to create an image. It may sound like some sort of Skyrim spell, but it works. Niépce used camera obscura to cast an image in which he would then etch to try and recreate using lithography. Despite this clever tracing technique, his hands weren't steady enough for his liking. He knew that certain chemicals reacted to light, so he tested to see if an image from the camera obscura would stay on a chemically coated plate.

Using a self-made shellac mixture, Niépce finally hit the jackpot. After discovering this huge advancement in art, he spent the next two years refining the process. He set up this technique on his windowsill from his workshop and technically snapped up the world's first photograph after eight hours of exposure. It was this process called the heliograph that was the first major step in photography.

COMMERCIAL PHOTOGRAPHY

In 1829, Niépce partnered with another French artist, Louis Daguerre. This was the start of the first commercial photography process. Unfortunately, Niépce passed away just four years later, but in his final few years with Daguerre, the pair continued developing the process and fine-tuning it. After Niépce's death, Daguerre kept trying to perfect this art of photography to push it to a commercial level, with a process he named 'daguerreotype' after himself, naturally.

He discovered that mercury could speed up the development process of a latent image from eight hours to just 30 minutes. That's a pretty impressive reduction in time. In 1839, he introduced this process at the meeting of the French Academy of Sciences in Paris and unveiled it to the public. Niépce's son, along with Daguerre, sold the rights for the daguerreotype to the French government later in the same year.

The daguerreotype process is performed on a sheet of copper that has a thin layer of silver without the use of a negative. This is a direct-positive process that would create a highly detailed image on the plate. This technique was pretty laborious though and was not easy for everyone to be able to carry it out.

Around the same time over in the UK, William Henry Fox Talbot was focusing on a similar technique, yet his idea had a fairly significant twist. Talbot was a scientist, inventor, a pioneer of photography, and also a Member of Parliament, a pretty busy guy to say the least.

With photographs taking up to eight hours, you wouldn't want to shoot a group photo.

Following a trip to Lake Como in Italy in 1833, Talbot attempted to draw the scenery with little success. This annoyance prompted him to invent a machine that would use light-sensitive paper to capture the scenery automatically. He kept perfecting his idea and just three weeks after Daguerre publicly unveiled daguerreotype, Talbot reported his 'art of photogenic drawing' to the Royal Society.

Instead of the image appearing on a copper plate, it based the prints on light-sensitive paper. This was an impressive feat, and as we all know now, paper is certainly the preferred media to print on. However, Talbot didn't stop there. He created three of the most important primary elements of photography; developing, fixing, and printing. Exposing photographic paper to the light created an image although it is far from simple and needed extremely long exposure times. He accidentally discovered that there was

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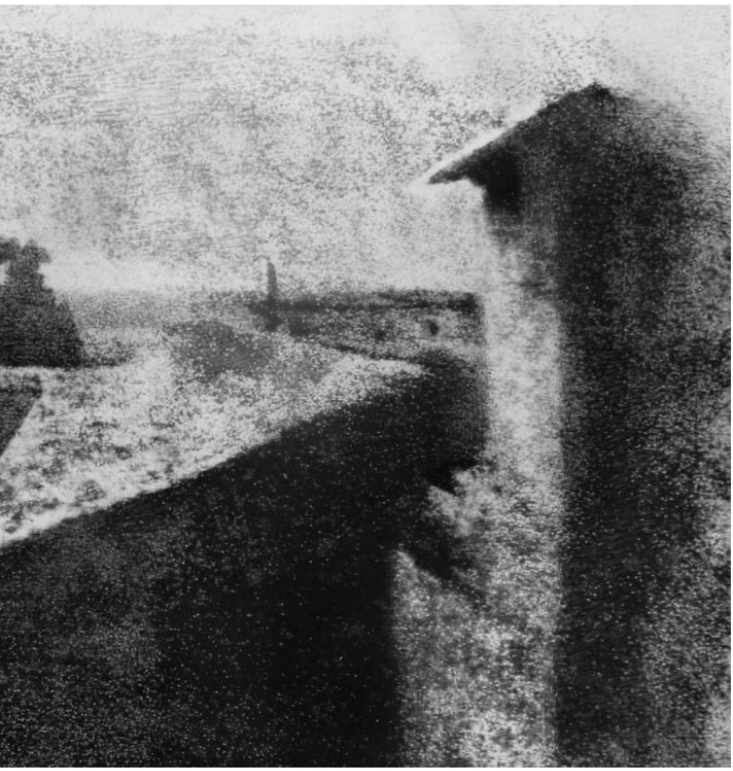


© JEN THEODORE ON UNSPLASH

indeed an image after a short exposure, and though, initially, he couldn't see it, he soon found that you could develop it into a negative using chemicals.

The image on this negative was then fixed chemically that removed the light-sensitive silver so that the picture could be seen in light. Using the negative from the image, Talbot discovered that he could print copies from this negative. This was more efficient than the daguerreotype as you could create any number of positive prints. This process was called the 'calotype' and was patented in 1841. As a result of his work, Talbot was awarded a medal from the Royal Society.

An optician named Charles Louis Chevalier was one of the first to produce cameras using the daguerreotype and calotype processes. These were popular at the time but photography still wasn't an easy and affordable thing that everybody could do. Physically, they were more compact versions of camera obscura but made out of wooden boxes with plates or light-sensitive paper inside.

From the 1850s to the late 1880s, there was a newer method of image processing called the collodion process. Invented by English sculptor Frederick Scott Archer, this included coating, sensitizing, and exposing the photographic material, and letting it develop in a dark room for around 15 minutes.

This process came about after Archer took a collodion solution then coated it on a glass plate. He then exposed this plate whilst it was wet to produce the image. It had some disadvantages though, one of which was that you needed to have a portable darkroom where this development process could take place. Any light that seeped into the darkroom and the image would be ruined.

This was one of the most dominant photograph-producing processes though up until the end of the 1880s. It was popular within wealthy communities and families and the photos produced eventually made it into newspapers. This rush of popularity meant that photography was soon becoming a part of society.

KODAK'S IMPACT

At the end of the 19th century, camera technology took a huge leap forward, thanks to a name that many people will still recognize to this day. The name Kodak was behind the boom in photography, with George Eastman the man behind the brand. On September 4th, 1888, Eastman received a patent for the world's first film camera, which opened photography up to all kind of enthusiasts.

However, a more affordable model, called the Kodak Brownie, came out at the turn of the 20th century. This basic box camera had a leatherette cover over its card structure and came with a wooden film case carrier. It introduced the 2.25-inch square format to the photography world. What these cameras brought was the availability to create physical memories and capture moments in time.

The Retina Series 35mm camera, released by Kodak in 1934, was another breakthrough for photography and for the company. This series was produced up until 1969 and during this period, the 35mm camera was one of the most popular formats of photography.

Many photographers often refer to the 35mm focal lens as the closest field of view to the human eye, giving a true representation of what the photographer sees, and it became one of the most popular formats. The decline of film as a format means that Kodak is no longer the name it once was, however, it was a true pioneer in the photographic industry.

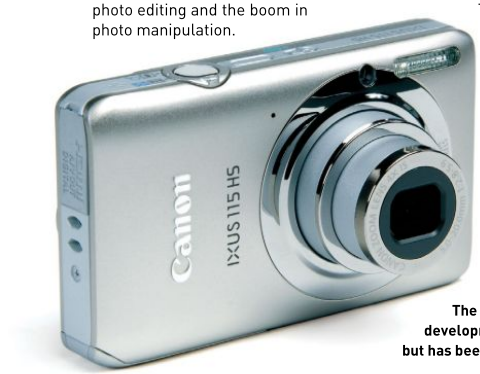
Kodak's pioneering Brownie model was one of the first affordable cameras.

THE EMERGENCE OF PHOTO MANIPULATION

THE TERM 'FAKE NEWS' might have been popularized only very recently, but incidences of 'fake news' certainly aren't a new thing. That brings us neatly to Hippolyte Bayard, another pioneer of photography in the 19th century. Bayard believed he was the father of photography, not Niépce, Daguerre, or Talbot. Frustrated by a perceived lack of credit for his work at the forefront of photography, Bayard created what could now be seen as the first example of clickbait—that's right, way before YouTube was even a thing, people were seeking attention through false claims.

Bayard could be considered the first 'influencer', also creating one of the earliest 'selfies'. Driven by the recognition the others had received, Bayard faked a photograph of his own suicide. In a grainy photo from 1840, Bayard photographed himself, partially clothed, lying against a wall after supposedly having drowned.

While faking a suicide image is a big no-no, Bayard's photo shows that image manipulation has been in existence right from the very start of photography. It also showed early on that a photograph could be deceitful and wasn't always a trustworthy source of information. Despite all the incredible places, people, and events that have been shot since, it's amazing to think that they were faking it even as far back as the 1840s. So, having determined it isn't a new phenomenon, let's skip forward to the start of digital photo editing and the boom in photo manipulation.



The digital camera was a significant development in the history of photography, but has been overtaken by the smartphone.

THE DIGITAL AGE

The fundamental technology of retouching didn't change too much until 1957 when Russell Kirsch created one of the first digital images by converting a picture of his three-month-old son into a digital file. It was created by scanning an analog picture, and though it technically wasn't a true digital image it was a step forward for digital photography. After this, many researchers and inventors experimented with digital photograph technology. They were focused on building machines that could take photos in a digital format.

In 1968, Peter Noble created a sensor that would convert light into digital data. Named the Active Pixel Sensor, it registered light across it and changed this information into digital data. It could create a digital image without analog images being scanned and was, therefore, one of the first digital cameras.

A researcher in the Kodak labs called Steve Sasson built upon this idea to create a digital camera that could capture and save electronic images. Sasson planned to make the first handheld digital camera, however, this didn't exactly go according to plan. Ending up being the size of a toaster, it wasn't what he had imagined.

The images it took were 0.8 megapixel black and white digital photographs and they were saved onto a cassette. Though it was a step backward in quality, analog was still far superior, this was a crucial creation for modern photography. This device worked, but it would take a further 16 years for digital cameras to be finally commercially available.

One of the earliest was the Logitech Fotoman in 1991. This was a vertically operated plastic camera, it had no rearview screen and had a viewfinder at the top left of the camera. It took black and white images at a 376x240 pixel resolution with 1MB of internal storage, or around 32 pictures.

Bayard's self-portrait as a drowned man is an early example of image manipulation.

To view photographs, you had to plug your camera into a computer, where you could view and edit your images using Logitech's digital camera software. This was groundbreaking stuff and caused a growth in digital cameras in the 1990s. Along with viewing your pictures on a computer and being able to digitally store them, of course, it gives you the option to tweak them with the camera's native software. However, at the start of the 1990s, this wasn't the only software that you could use to edit your pics.

THE BIRTH OF PHOTOSHOP

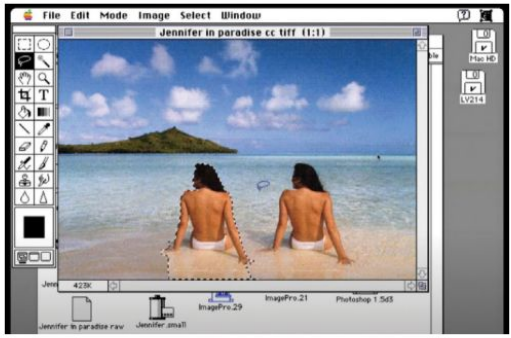
The late 1980s saw the creation of the best selling and most popular photo editing program to date, Photoshop. This significant application was created by the Knoll brothers, John and Thomas. John worked for Lucasfilm's Industrial Light and Magic special-effects company and while there he discovered the Pixar Image Computer. This piece of equipment was able to create a digital image from film that could be manipulated and then reinserted back into the film. It was a computer specifically for image editing.

The problem was the astronomical cost of the machine and the fact that it could only be operated by a specially trained technician, which wasn't either convenient or practical. John loved this idea though and, coincidentally, when talking to his brother about this, discovered that he had been working on a similar piece of software for the Macintosh Plus at the University of Michigan.

The brothers collaborated and continued to work on their idea until they had developed a sophisticated piece of software they could present to the powers that be. They needed an image to use for a demonstration, so John scanned a 4-inch by 6-inch print of a photo of his girlfriend he had taken in Bora Bora that came to be known as 'Jennifer in Paradise'.

© WIKIMEDIA

Photoshop has come along way since version 1.0 hit our desktops in the early 90s, but the iconic toolbar remains.



The famous 'Jennifer in Paradise' image that John Knoll used to demonstrate the capabilities of Photoshop.

The earliest version was named 'Display' and was soon changed to 'ImagePro'. After Thomas took a six-month break from his studies, he and his brother developed the program into a fully functional image editing application. By then, the 'ImagePro' name had been taken, so they settled upon 'Photoshop' instead. The piece of software was distributed alongside hardware sold by Barneyscan, which had created the first high-quality, 24-bit desktop color scanner. This way, the first 200 copies of the Photoshop software had been sold.

The Knoll brothers presented their software to Apple and Adobe, with Adobe eventually purchasing the license to distribute Photoshop in September 1988. Photoshop 1.0 was released in February 1990 on Macintosh computers and came with a host of features, including a color correction facility with balance, hue, and saturation, image output optimization, curves, levels, and a clone tool. It also featured the lasso tool, brush tool, and magic wand. You could also change the opacity and colors of sections from an image. These features have always remained in the software and are still as important to the graphic designers of today as they were back then.

Of course, as well as having these new manipulation tools, Photoshop also worked well as a standard image editing suite with the ability to adjust your image's values, and crop it too. Photoshop was a great package to get anyone into the editing side of photography, whether you were just having some fun, perfecting your images, or looking to start a career using this new technology, it was the start of something massive for everyone.

HISTORIC IMAGE RETOUCHING

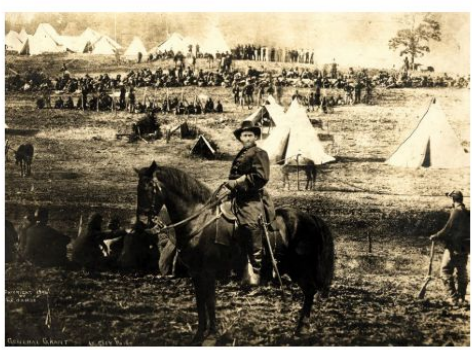
Back in the 19th century, image manipulation was first introduced as retouching. This was a highly skilled and time-consuming job that only the richest of photographers could afford to make slight adjustments to their pictures.

This process remained unchanged for a long time, right at the start of photography regardless of the type of negative. After a negative was exposed, it was processed using chemicals in the darkroom to develop and then fix the resulting image.

To protect it from damage, some photographers varnished their negatives while others retouched them first and then preserved them afterward. It was carried out on a special table that had an angled surface that you could alter.

The negatives were shone through from behind once they had been placed inside a frame on the angled surface. These were shone through using a reflective surface or preferably an adjustable mirror. To stop light shining in, it had curtains running down each side. The majority of these manipulations were on the negative side with emulsion coated on it.

More detailed work required the retouchers to use a scalpel or a similar blade. This etching was taken out by experienced retouchers only and was an extremely delicate procedure. Etching was a crucial part of perfecting clients' images for portrait photography. Before starting to edit, the negative had to be prepared by polishing it with pumice powder.



According to the Library of Congress, 'Ulysses S. Grant at City Point' is a montage or composite of three different images and does not actually show General Ulysses S. Grant at City Point.

A retoucher would focus on lightening areas first then darkening others, using graphite pencils, ink, or watercolors. A retouching mixture was then applied. In case of a mistake, this dried layer could be easily removed—a 19th-century version of CTRL+Z.

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MODERN EDITING

Phones have quickly taken over as the most popular form of camera.

IT'S FAIR TO SAY that the camera has changed the world we live in. With the World Wide Web going live in August of 1991, digital photography and image manipulation boomed alongside the growth of the internet. The introduction of Photoshop made manipulation both more accessible and more convincing too. Everything we take for granted today, including brightening, sharpening, contrast, hue, and saturation levels, we owe to the advancements of digital photography and Photoshop.

In the early 2000s, Sharp introduced the camera phone. By today's standards, they were shocking images, but the idea of being able to carry around a 2-in-1 camera and phone device was a winner. However, due to the poor quality of the camera phone, people still continued to carry a separate digital camera with them. But as time progressed, so did the quality of all the components of image manipulation. Digital cameras received sensors with larger megapixel capabilities. Better quality images allowed more impressive photo manipulation. Image editing software also vastly improved through the 1990s and the early 2000s, with Photoshop paving the way for graphic designers.

Since its release, Photoshop has been the industry standard. It made its way through all types of media, from magazines to album art, posters to website designs. Other image editing programs sprung up, including Microsoft's Photo Editor which then became Microsoft Office Picture Manager. These programs, however, didn't have the same scope as Photoshop and were for more generic image editing. Most cameras came with accompanying software that also allowed for tuning too. Technology was evolving at such a rate that everything kept improving in tangent with each other. Throughout the 1990s and 2000s to a point where digital photography and manipulation is the norm. You could now practically design and depict whatever you wanted in this modern digital age. No longer did you need a 'retoucher', everybody could attempt image manipulation of their own.

THE PROS AND CONS

Towards the end of the 2000s, phone cameras improved at a rapid pace. The iPhone played a huge role in boosting the popularity of the smartphone and one thing that constantly evolved was their cameras. People were starting to take high-quality images straight from their phones, uploading them to their computers and editing them.

However, with the rise of the front-facing camera and the growth of social media sites such as Facebook and Instagram, we started to see an uglier side of photo manipulation in the past decade. Of course, the technique of airbrushing has been used for years, where models have been edited to appear slimmer and more aesthetically pleasing for magazine covers. The beauty standards created by such unrealistic images is just one issue with image manipulation, creating unhealthy expectations that have a huge effect on younger generations. With everyone able to take pictures and airbrush themselves in a matter of minutes, image manipulation on social media is an ongoing problem.

The ease by which photos can be manipulated today has caused a proliferation of fake news, misleading advertisements, and even fraud. There's a fine line between manipulating images for artistic license and for the purpose of deceiving people, whether for financial or political gain, but where do you draw the line? You might not think that cropping an image is deceitful, but what information has been left out? If one side of an argument or fight has been cropped, for example, are you getting the whole story? When photo manipulation is carried out by media organizations with the power to influence millions of people, we're delving into the unethical side of image editing.

Image manipulation isn't all bad though. Who knew how much fun you could have by turning yourself into a dog on Snapchat, for example? It can also be used to let your imagination flow by creating amazing pictures, great pieces of art, or hilarious memes.

Technology is moving at a ridiculous pace and we no longer keep physical snaps, we either digitally store them in the cloud or share them online for the world to see. With over 1.8 billion photos uploaded every day on the internet, it's almost impossible to tell what's real and what's not. In just 30 years, image manipulation and digital photography have certainly changed the world. The question is, though, is it for better or for worse?

As smartphones evolved, so did their cameras.

© PHOTO BY ANDREA ZANENGA ON UNSPLASH

IMAGE EDITING SOFTWARE FOR THE PC

VERDICT 9

$239.88 prepaid annual plan, $21.99 prepaid monthly plan, $31.49 contract-free monthly plan, www.adobe.com

Adobe Photoshop

Photo manipulation wouldn't be where it is today without Adobe's Photoshop program. The pioneer of image editing was added to the Oxford English dictionary as far back as 2006 and is now equally known as a verb as it is a piece of software.

Photoshop is a raster image editing suite for macOS and Windows, but there are also lighter versions available for mobile phones. You can use this application for image editing, graphic design, or digital paintings.

It has become the industry standard now and though alternatives are getting better, Photoshop is the best all-around package.

Of course, all this expertise comes at a price. You'll need Adobe's Creative Cloud and then pick a plan that suits you. You'll be expected to pay a minimum of $31.50 a month if you want a contract-free license, or a prepaid $240 a year. That works out cheaper in the long run, but is still a hefty sum for one program.

If you are planning to use other Adobe programs, such as Illustrator, it's best to find a suitable deal on their site.

VERDICT 8

$54.99, www.affinity.serif.com

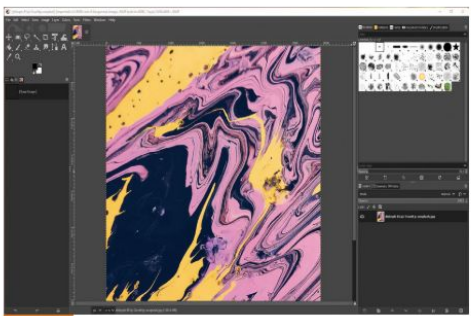
Affinity Photo

With a one-off payment and similar tools, Affinity Photo is a rival to Photoshop. It was released as a free beta test version in February 2015 and, following a huge amount of interest, was fully released in July that same year.

Previous to this, Serif, the company behind Affinity, had a product named Serif PhotoPlus for Windows that was another image editing suite but this was discontinued following the release of Affinity Photo.

It offers a similar layout and selection of tools as its Adobe Photoshop rival, but with a 60fps pan and zoom, it's a little upgrade. If you go from this application to Photoshop you'll definitely see the difference between the two. Affinity Photo looks much silkier and gives it an illusion of a performance increase and a snappier application helps with your productivity.

Overall, it's a solid application that closely rivals the industry standard. The main benefit though is the one-time payment with no subscription. So if you are trying out image manipulation this could be a great first application. Of course, like Photoshop, both offer trials.



VERDICT 8

$Free, www.gimp.org

GIMP

The awkwardly named GIMP actually stands for GNU Image Manipulation Program. It is a cross-platform image editor available on GNU/Linux, macOS, Windows, and more.

The one thing that makes GIMP so good is its versatility. Its open-source nature means that you can change its source code and distribute your changes if you want to. Sure, most people won't take advantage of this but it's there for good measure.

GIMP is a good all-rounder that offers high detailed manipulation for graphic design work. Though it doesn't quite match up to the high standards set by Adobe Photoshop, this community-driven and developed software has all the tools suitable for you to get the job done. Its great color management features ensure high-quality color reproduction across physical and digital media.

GIMP also has solid programming integration, which means customizable features and community-made plug-ins. Whether that is image editing, graphic design, GIMP is a solid application, and best of all, it is free.

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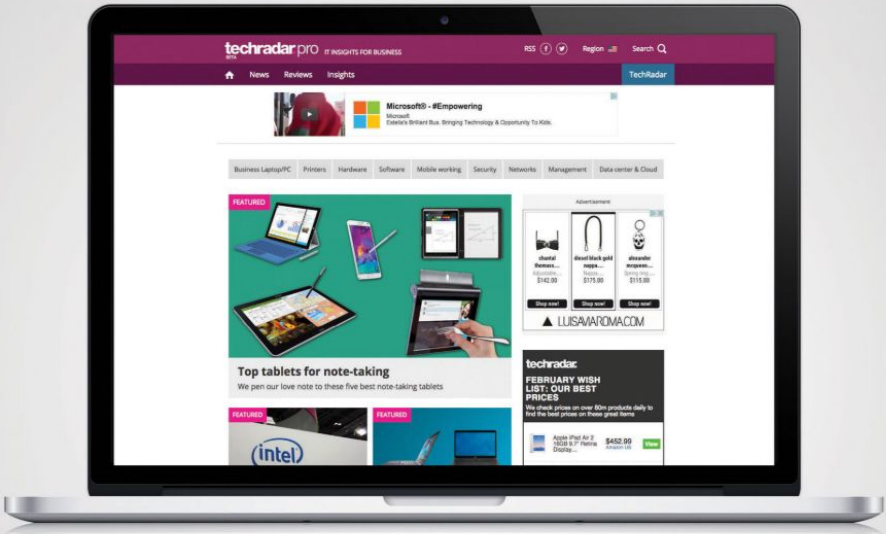
IT INSIGHTS FOR BUSINESS



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HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH

START MENU BACK TO THE LEFT

If like us, you have been able to update to Windows 11, you may have noticed Microsoft's big change—the centralized start menu. If you're not a fan, then fear not, you can easily move this back down to the bottom left corner. Right-click any blank part of the taskbar and click on taskbar settings. Then scroll down to find taskbar behaviors, then taskbar alignment. From here, you can set it back to its natural habitat on the left.

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66 Downsize your PC case in this month's Build it

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SAM LEWIS
STAFF WRITER

CODING MY CAR?

Yes, you read that right. Instead of trying my luck with computer coding, I thought I'd go over to the automotive world. I've seen OBD scanners online and they have intrigued me for a while. They are little devices that plug into your car's OBD port, usually located under the steering wheel, and read engine fault codes.

I treated myself to a CARLY, which connects to your phone via Bluetooth. Simply plug it in, turn on your engine and use the app to scan your car. I was planning to sell my VW Golf but wanted to check for any hidden fault codes. Thankfully, it was fine but a scan would give you a description of any codes and what they mean. It also checks the overall health of the vehicle, if the airbags have been previously set off or if the mileage has been tampered with.

Now, here's the coding bit—you can customize the car's ECU! I stopped mine beeping when I unlock it and turned on a feature that locks the doors automatically when driving over 10mph.

You can either pay for the scanner and a lite version of the app for a basic scan or choose a package that comes with a scanner, smart mechanic, and vehicle information. Hopefully, this device will save me some money next time any warning lights appear on my dashboard.

↘ submit your How To project idea to: editor@maximumpc.com

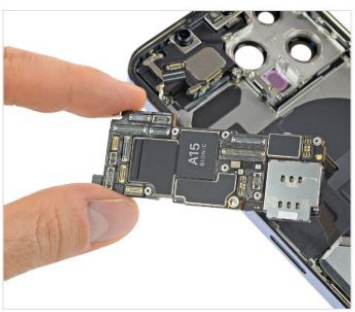
IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

iPhone 13 Pro

Removing the screen is, thankfully, an easy procedure with the right tools



The layered logic board is even smaller this year, but unfortunately the SIM card reader is now baked onto the board

Did someone say more cameras? However, there isn't much difference here compared with the iPhone 12

BACKGROUND

On the outside, this iPhone looks like an incremental update, but we have a feeling there's more lurking beneath the surface.

MAJOR TECH SPECS

- A15 Bionic SoC with a new 5-core GPU, 6-core CPU, and 16-core Neural Engine.
- 6.1-inch (2532 × 1170 pixels) Super Retina XDR OLED display with ProMotion.
- 12MP triple camera system with ultra-wide-angle (ƒ/1.8), wide-angle (ƒ/1.5), and 3x telephoto (ƒ/2.8) cameras, LiDAR module.
- 6GB of RAM and 128GB of storage (configurable up to 1TB).
- Sub-6GHz 5G (and mmWave on US models), 4x4 MIMO LTE, 2x2 MIMO 802.11ax WiFi 6, Bluetooth 5.0, Ultra Wideband, and NFC.
- MagSafe 15W wireless charging.
- IP68 water-resistance rating.

KEY FINDINGS

- From the outside, the iPhone 13 Pro looks swollen compared with last year's model, but it's what's inside that counts. The camera bump means that the phone doesn't lay flush on a flat surface. Hopefully, the micrometers of extra focal length will help justify this Carolina Squat. We'll have to wait and see!
- The 13 Pro inherits one of our favorite smartphone opening procedures. The display comes off first, like opening a slightly sticky book. Inside, we spot some labeling—it's almost as if they were expecting us! For starters, the digitizer and display cables seem to have joined forces. The upper sensor cable is off on its own near the top, and the Taptic Engine appears smaller than the 12 Pro's shaker, but it's bulked up, clocking in at 6.3 grams and 869.4 mm^3, versus the 12 Pro's 4.8 grams and 764.27 mm^3.
- Unlike the vanilla iPhone, this year's Pro camera arrangement looks the same (and beefier than the 12 Pro's array). How will people know you've upgraded?! Maybe you should just... not?
- This beefy L-shaped battery caps out at an expected 11.97Wh compared to the 10.78Wh obelisk in the iPhone 12 Pro (and non-Pro), but loses out to the standard's 12.54Wh rectangular cell. The fancy Pro screens let them sip battery, leading to better battery life. After rumors that battery swaps wouldn't be possible, we're happy to report that our battery swap tests were successful. Apple hasn't given up its scare tactics, so you'll get a warning notification. Be brave and keep fixing!
- Up top, we find the relocated earpiece speaker, complete with a snoot between the front-facing camera and Face ID hardware that connects to a channel that directs sound out the top of the display. With its cables running underneath the earpiece speaker (underneath the logic board) the front-facing camera hardware—the enabler of the new, shrunken Notch™—isn't exactly a piece of cake to access. But, at last, we have arrived!
- Repairability Score 5 out of 10 (10 is easiest to repair). Display and battery replacements remain a priority in the new iPhones' design. Most other components are modular and easy to access. The multitude of screw types makes repair more difficult than necessary, but at least they aren't glued. Waterproofing methods complicate some repairs but make water damage less likely. Double glass means double drop damage and, despite the improvements in durability, there's no easy way to replace the rear glass. Software component pairing complicates many repairs, undermines the credibility of third-party repair, and reduces critical functionality of the device when repaired without Apple's proprietary calibration tools.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Dual lighting in Photoshop

YOU'LL NEED THIS

ADOBE PHOTOSHOP CC 2020
https://www.adobe.com

YOU MAY HAVE SEEN THIS LIGHTING EFFECT used in advertising, films, and portrait shots. Bathing the main focal point of your image in some immersive lighting focuses the attention there and is a great way to highlight what really matters in your shot. In this tutorial, we will be using layer masks, blending modes, and gradient maps. It's also worth checking out our previous tutorial on gradients for illustrators to get a feel for how gradients work.

These techniques will combine to give the illusion of two separate light sources hitting the main subject. You can expect a more rewarding outcome if you start with an image that has strong shadows and highlights or a strong contrasting background. You can create this effect naturally in the photo studio with lightboxes and color acrylic films but we know that method isn't the easiest or most practical way to achieve the effect. We will be heading over to Unsplash to pick out a license-free image from Emrecan Arik to use for our tutorial. If you take your own imagery and have something that fits the criteria then go ahead and practice on your own material. The best way to get familiar with these techniques is by repeating them and if you have a range of images, you can try this on a few of them. –SAM LEWIS

1 CHOOSE YOUR SUBJECT

Before we get stuck in, open up your image in Photoshop. To keep things organized, we renamed our image to suit today's tutorial so when we save it, we won't need to rename the PSD file. We also made a duplicate original layer to copy in case we need to go back to the start or take things from the original picture.

» The first thing we need to do is select the subject. There are a few ways to do this—you could use the pen tool, the magic wand tool (if the object has a strong contrast from the background), the lasso tool, or the quick selection tool. However, one of the easiest ways is to head up to the select tab at the top and from the drop-down menu click subject, and it automatically selects that for you. If it doesn't highlight enough of the subject, use the quick selection tool to tidy things up.

2 BLACK AND WHITE CHOICES

Once you are satisfied with your selection, head into the layers panel and open up a group layer with your main layer selected. After this click, make a mask of this—the mask button is found in the same place as the group icon. When you apply a layer mask to a group, it makes it possible to manipulate multiple layers with just one layer mask [**Image A**]. We are now going to change the image to black and white to desaturate it. This icon is in between the first two and is called the adjustment layer icon, click on that and find black & white.

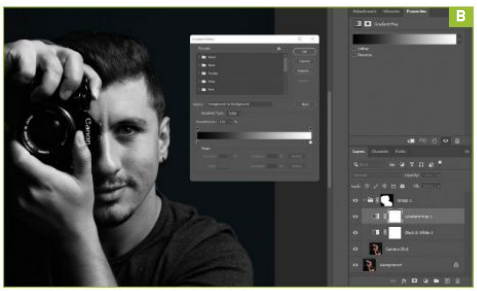
» Now click on the left thumbnail icon on the black and white layer, this allows you to change the foreground and background colors if they aren't already the default colors. These are black as the foreground and white as the background.

3 ADD SOME COLOR

Head back to the adjustment layer icon and select the gradient map option. This is where we will start to create our highlight colors. The foreground and background colors that we set before this step will be used in the gradient map bar you will see in the right properties panel.

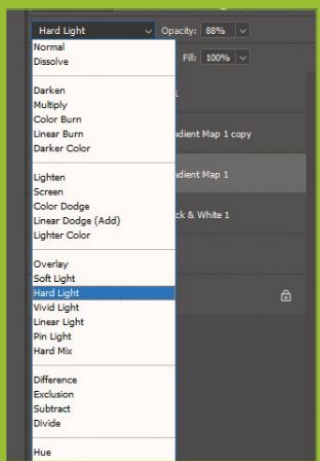
» Click inside this gradient bar and it will open up a gradient editor pop-up window and you will see another gradient bar. You don't necessarily need to change anything else other than the color in the bottom right indicator on the bar.

» Double click on this to change the color. You can change this to any color you like, but for this tutorial, we are using a bright blue. Then click OK on both open windows to close them down. The gradient map assigns a color to corresponding brightness levels. You will now notice in the gradient bar colors to the left are mapped to the darker tones in the image and vice versa [**Image B**].



© ADOBE

BLENDING MODES



Blending modes are essentially lighting effects that will change accordingly to the light values in your image, or selected layer. Working with these modes in Photoshop is often an experimental experience. The first time you try using them, your image might come out perfectly, or it could end up being completely ruined.

One thing to note is that the opacity slider in the layer panel controls how much the blend affects the layers below it. If you want a weaker blend, reduce the opacity and increase it for a stronger effect.

To help understand the blending modes a little more, they are split up into six categories within the drop-down menu. At the top is the normal group that contains the default normal blend mode and a dissolve option. Below that is the darkening category with these options: darken, multiply, color burn, linear burn, and darker color. Underneath that is the lightening category with: lighten, screen, color dodge, linear dodge (add), and lighter color blending modes.

The next category is for contrasting blending modes, you can find options such as the overlay, soft light, hard light, vivid light, linear light, pin light, and a hard mix mode here. After that are the inversion and cancelation modes with options such as difference, exclusion, subtract and divide.

Finally, the last options are for components. These are the hue, saturation, color, and luminosity. These categories make it easier to understand what these blend modes do and what they affect, but the best method is the trial-and-error route. Play around with them as one blend mode could do something completely different to the next image you use it on.

4 TRYING TO BLEND IN

In this step, we will use some blending modes to make things look more realistic. Head over to the blending modes drop-down menu at the top of the layer panel. By default it will say normal, so click this and find the hard light option. If this looks too harsh, you can decrease the opacity values to around 80-90 percent or whatever suits your image best [**Image C**].

›› Now we are going to add the secondary light source color into the image. This source will be coming in from the right side of the image, so we have to erase where we think this new light source will affect. To do this, select a brush tool and make sure the size is fairly large for a smoother selection, also turn the hardness of the brush down to zero percent. Make sure that black is still the foreground layer and the gradient map layer is selected. You will see a white box around this thumbnail indicating that it is. Take your time with this stage, draw out where you think the secondary light source will hit the subject.

5 INVERTING REALITY

After this is completed, you should have a similar result to the image below. Next, we need to duplicate this gradient map layer. CTRL + J works as a shortcut or you can go to the layer drop-down menu at the top, hit new, then select layer via copy. We then need to invert this layer, so either use the CTRL + I shortcut or go to the image drop-down menu, click on adjustments, and then invert.

›› Once it has been inverted, we are going to change the color of the right side to red, which will create a nice contrast from the blue. Make sure the new duplicated gradient map layer we have just inverted is selected.

›› Go into the properties tab and click on the gradient bar to open up the pop-up window [**Image D**]. Double click on the blue bottom right color indicator again and change it to red or whatever color you want. Select OK on both the open windows to close them down.

›› Once this is done, it may look good already and that's fine. However, it doesn't always pan out so perfectly. Our image was too bright so we chose a darker red and turned the opacity down a little. We then changed the blue and red areas further by using the brush tool on both gradient map layers to add or decrease areas of color. Eventually, we ended up with a believable light effect. It's a fun way to add some wow factor to an image so keep practicing with this one.

Machine of the Month: Sinclair ZX80 & ZX81

YOU'LL NEED THIS

A COPY OF ZESARUX
available from GitHub.
https://github.com/chernandezba/zesarux/releases

FOR FANS OF BRITISH MICROCOMPUTERS, the Sinclair ZX80 and its successor, the ZX81, were integral to establishing the home computing scene. The brainchild of British inventor, Sir Clive Sinclair, the ZX80 first brought affordable home computers to the masses in 1980.

As we began our research for this column, we heard the news that Sir Clive had passed away, aged 81. So it seems an even more appropriate time to pay tribute to a computing legend by covering the machines that kick-started Britain's coding revolution. **–JOHN KNIGHT**

1 DEVELOPMENT

Before the ZX80, Sinclair Research was already well established in the electronics world, pioneering devices such as cheap calculators and pocket televisions. It had developed a rudimentary computing kit under the former name of Science of Cambridge—1977's MK14. But from 1980, the Sinclair name would forever be linked with affordable home microcomputers.

» In the late 1970s, computers were far too expensive for most households. Obsessed with making sophisticated electronics available to all, Clive Sinclair envisaged a new microcomputer that, with clever simplification and cost-cutting, was affordable.

» Chief design was entrusted to Jim Westwood, briefed with something that would cost under £100 while still making a profit.

» Cost-cutting was applied. The base model came with 1KB of RAM and no sound output. Video output was black and white and the membrane keyboard was the worst in all Christendom.

» It doesn't have a dedicated video chip but uses an ingenious workaround. By using static RAM instead of dynamic RAM, Westwood was able to exploit the Z80 processor's unused dynamic RAM interface to make the CPU do video processing.

» The downside was that the ZX80 couldn't process video output and keyboard input simultaneously, resulting in an annoying screen flicker with each keypress.

» Despite its flaws, the ZX80 was a huge success, retailing for £100 ($138) or £80 ($110) in kit form. However, customers soon discovered they couldn't do much with 1KB of RAM, making the 16K RAM expansion pack a must-have accessory.

» The following year, Sinclair upgraded the ZX80 design with the ZX81, addressing many flaws. The screen flicker was resolved by introducing "SLOW" mode, which used the Z80's interrupt mechanism to control when to output the TV signal. The ROM was upgraded to include floating-point computations, additional commands, and ZX Printer support.

» The ZX81 used an Uncommitted Logic Array (ULA) chip from Ferranti, reducing the chip count from 21 in the ZX80 to just four. This allowed Sinclair to sell the ZX81 even cheaper. In March 1981, the ZX81 cost £70 ($96) assembled, or £50 ($69) for a kit.

2 GAMING

ZX80 games aren't common, but as the ZX81 doesn't have proper graphics, its games were based on text block characters. They were often ambitious within these limitations.

» *The Gauntlet* (1982) is a great arcade bomber, and *Mazogs* (1982) is an intriguing maze explorer with cool aesthetics. *3D Monster Maze* (1981) and *3D Defender* (1981) push the limits of ASCII art with first-person 3D perspectives. Brazilian platformer *Em Busca Dos Tesouros* (1986) sports impressive animations and brutally difficult gameplay.

» Both machines had dedicated masochists who squeezed whole games into 1KB for stock machines. *1K Space Intruders* (ZX80, 1981), *1K ZX Chess* (ZX81, 1982), and *Nohzdyve* (ZX81, 2019) are all examples of coding at its absolute leanest.

» Clever coders eventually figured out ways of piecing together one-line slices of Sinclair's character set to emulate the look and feel of sprite graphics. Games like *Forty Niner* (1982) and *Rocket Man* (1984) achieved impressive results, though the geometry looked wonky.

3 LEGACY

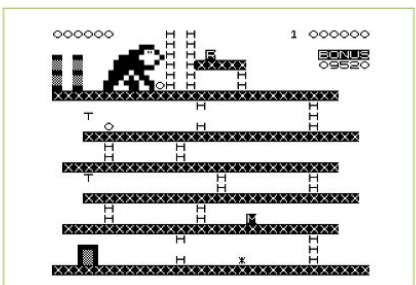
While the ZX80 had a strong showing with sales of over 100,000, they were dwarfed by the ZX81, which enjoyed sales of more than 1.5 million.

» An enormous fan base developed and conventions were flooded with Sinclair users. Third-party vendors sold hardware add-ons, such as disk drives, improved cases, and better keyboards. Software houses sold cheap software on cassette, along with endless programming manuals.

» Both computers spawned clone machines. The ZX80 had clones in Brazil and the US, while the ZX81 had clones in Brazil, Argentina, Hong Kong, and China.

» In the US, third-party production was licensed to the Timex Corporation. Its first launch was the Timex Sinclair 1000, an NTSC-modified version of the ZX81 that shipped with 2KB of RAM.

» Initial sales were strong but diminished after customers discovered the limitations of so little RAM.



» Sinclair's machines are treasure troves for ASCII art fans. Paul Farrow's *ZX80 Kong* (2010) nicely re-imagines the classic *Donkey Kong* game via text characters.

›› **Despite their shortcomings (and mockery by Red Dwarf!), these machines have the magic ingredient of classic home computers: a soul.**

Apparently, Timex hadn't debuted with RAM expanders, though this may be internet misinformation. Improved models followed, with better keyboards and more RAM, but American rivals soon price-matched Timex with stronger computers.

›› The reign of the Sinclair ZX81 ended with the arrival of the ZX Spectrum in April 1982. Users and developers were both quick to move to the new machine, which had both sound and color. Games for the ZX81 dried up shortly afterward and the machine itself was discontinued in 1984.

4 EMULATION

Numerous emulators are available, but our favorite is ZEsarUX. It is simple to use, doesn't require system ROMs, and emulates other machines, including Sinclair clones.

›› ZEsarUX supports Windows, Linux, and Mac OS, plus a host of lesser-known systems.

›› The URL for the emulator is https://github.com/chernandezba/zesarux/releases, but you could just google "github zesarux" instead.

›› On the right of the project's GitHub page, there is a link called "Releases". Platform-specific binaries are provided in compressed files, and some Linux distributions may already have ZEsarUX in their repositories.

›› For Windows users, extract the ZIP file and open the destination folder. ZEsarUX doesn't come with an installer, so you will have to open the executable manually. Double-click zesarux.exe to start the program.

›› For Linux users, download and extract the binary tarball. Open a terminal in the new folder and enter the command:

```
$ ./zesarux
```

FINDING SOFTWARE

While ZX81 software is plentiful, ZX80 software is difficult to find, though there are plenty of programming manuals. There are links on forums, such as sinclairzxworld.com, but a great source of ZX80 software is Paul Farrow, who runs the Sinclair ZX Resource Centre at www.fruitcake.plus.com. Paul has an impressive collection of materials for both the ZX80 and ZX81. ZX80 games include conversions of gaming classics such as *Kong* and *Pacman*, without screen flicker.

Paul is renowned for pushing the limits of Sinclair machines. His 2016 title, *Against the Elements*, pushes the ZX81 to near-Spectrum levels of performance, with color support via his Chroma SCART interface.

For other ZX81 sources, www.rwapsoftware.co.uk has received permission to host the software on display. Paul also asked us to link the archives of www.zx81stuff.org.uk, and Bob Smith's new games at bobs-stuff.itch.io.

5 USAGE

Once inside ZEsarUX, you will be greeted with a help screen, press Enter to dismiss it. ZEsarUX will probably run a ZX Spectrum by default, but you can easily switch to a ZX80 or ZX81.

›› If the main menu hasn't already been brought up, press F5. From the main menu, choose Machine → Sinclair Research, then pick either the ZX80 or ZX81.

›› The emulator will now reset into an empty BASIC prompt. Don't panic, you won't have to learn any commands. Just open the main menu again and choose Smart Load. From here, open your cassette files and it should open automatically. If your files are still zipped, ZEsarUX will simply treat the ZIP file as a folder, and you can open cassette images from within ZIP files.

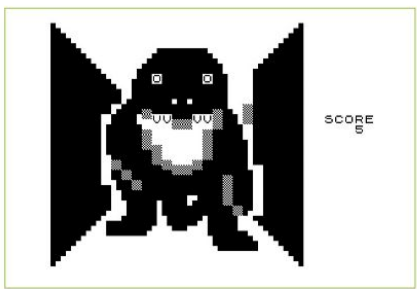
›› If your program isn't doing anything (you may see a "0/0" message) press R, which will enter the RUN command, and press Enter. This should get you out of most jams, though it's also worth remembering the Continue button, which is mapped to the C key.

›› In a weird case of early British terminology, Enter will generally be referred to as "Newline". As for controls, many games will work with your PC's cursor keys—a luxury of modern emulation—but Sinclairs usually have their cursor keys mapped along keys 5 to 8: **5 = Left, 6 = Down, 7 = Up, 8 = Right**.

SPECIFICATIONS

SINCLAIR ZX80 & ZX81 (1980, 1981)

CPU:	Zilog or NEC Z80 clone @ 3.25MHz
RAM:	1KB, 16KB max (ZX80), 64KB max (ZX81)
Launch price:	£100/$138 (ZX80), £70/$96 (ZX81)
Graphics:	24 lines × 32 characters, or 64 × 48 pixels graphics mode (ZX81)
Sound:	None
Storage:	Cassette
OS:	Sinclair BASIC
Released:	January 1980 / March 1981
Production:	1980 / 1981-1984
Worldwide sales:	100,000 / 1.5 million



›› ***3D Monster Maze*** **(1981) for the ZX81 was hailed as a technical triumph, being one of the first games with a 3D first-person perspective available for home systems.**

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Security and the Internet of Things

YOU'LL NEED THIS

PC, ROUTER(S), HOME NETWORK, IOT DEVICE(S)
Internet connection
Wi-Fi

THERE'S A STORY THAT GOES around cybersecurity events about a casino, somewhere in North America. It had a fish tank, and in that watery fish home was a thermometer. For reasons best known to the casino management, the thermometer was an IoT (internet of things) device and reported the tank's temperature via Wi-Fi. However, it wasn't particularly secure, and so hackers used it to gain a foothold in the gambling establishment's network, eventually escaping with a database containing the details of high-rolling customers. We hope the aquarium housed a marine environment, as it would make comparing the heist to the *Oceans 11* movies easier.

That might sound pretty amusing when it happens to wealthy people with more money than sense, but a general lack of security in IoT devices is far less funny when it allows hackers to cuss at you through an insecure IP camera, as happened to one Dutch woman recently.

The fact is that many IoT devices are insecure from the moment you install them on your home network and allow them unfettered access to both it and the wider internet. Basic security issues, such as generic admin passwords and having remote access enabled by default, are relatively easy to fix, but there are also things you can do on your router to help increase security, and prevent yourself from being 'fishtanked'. **–IAN EVENDEN**

1 NETWORK SECURITY

There are plenty of steps you can take around your home network to reduce the likelihood of anyone making ingress from outside. The first is changing the name of your SSID to something that doesn't identify the manufacturer of your router. Remember that your chosen name will be broadcast into neighbors' houses, so hilarious names such as 'FBI Surveillance Van' or 'Number 42 We Hate Your Music' should definitely not be on the list if you value your neighborhood relationships. Try not to put any identifying information in the name, so not 'This Is The Goldbergs' Netgear Router' [**Image A**].

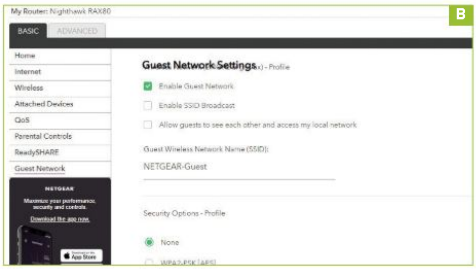
›› If you can live with a hidden SSID, then all the better, as your wireless network won't be nearly so obvious to someone with a laptop full of intrusion tools and a nose for mischief. Not everybody is prepared to live with the inconvenience, however, so the next thing to check is that you're using the best encryption protocol your router can manage. New devices must support WPA3 to get their Wi-Fi certification, but WPA2, with its mandatory AES encryption, is still a valid option. If you're using WPA, or even WEP, and are concerned about security, then getting a new router should be moved to the top of your to-do list. Likewise, if you have an older device that can't access a WPA2 network, it's better to upgrade it than to compromise security.

2 SEPARATE YOUR BANDS

Most IoT devices connect at 2.4GHz, so you can move devices to the 5GHz band, if your router supports it, with no security implications. The 2.4GHz network has a better range but lower speed so can potentially pick up security cameras and Wi-Fi lights further away without needing a booster. This leaves the faster 5GHz network uncluttered for your phone, tablet, and PC. You get a faster and more stable connection through the Ethernet, so fixed devices, such as smart TVs, desktop PCs, NAS boxes, and media servers, can be wired in to take pressure off your Wi-Fi bands.

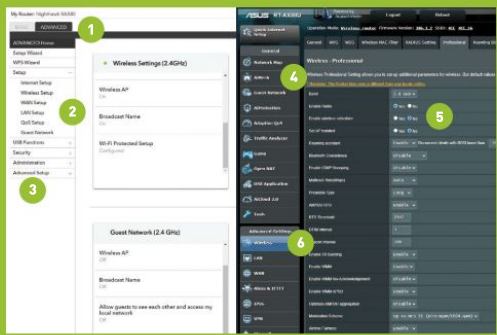
3 GUEST NETWORK

Many routers support an additional virtual 'guest' network that is cut off from the primary one you use. It's not meant as a security measure, but something you can switch on when family comes to visit to save giving them your password, or if you're running a shop and want to offer customers internet access. However, because of its isolation from the rest of the network, it does have security benefits—as long as that isolation is turned on. For some routers, it's on by default, on others you need to check a box. Some go further and isolate devices on the guest network from each other.



© NETGEAR

ROUTIN' TOOTIN'



1. ADVANCED
This is where all the interesting tools are, though you can find security options in Basic too.

2. GUEST NETWORK
Both our Netgear and Asus (running Merlin firmware) routers make it easy to find Guest Network options.

3. EVEN MORE ADVANCED
This is the home of the VLAN settings, which you should read up on further before tackling.

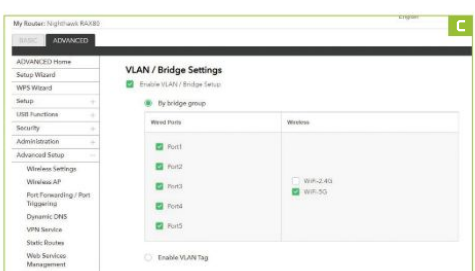
4. ASUS GENERAL SETTINGS
The Guest Network is high up on Asus's list, and it offers three to Netgear's one.

5. WIRELESS SETTINGS
Here, you'll find security, filtering, a block list, and advanced Wi-Fi settings, all in one place.

6. AP ISOLATED
This is a useful setting that can cut off one access point from the rest of the network.

›› This is fine but cuts both ways. If you've isolated a device so it can't hop onto your main network, it means you can't get to it from there either. Luckily, most apps such as Alexa, Ring, and Logitech don't access your device directly across the network, but both the app and the device talk to the same server out in a data center somewhere. If you need to connect directly to the IP address of your device that's within the internal pool doled out by the router's DHCP server, then you're out of luck and will need to either reduce security or attach it to the main 2.4GHz network.

›› Our consumer Netgear AX router has little in the way of options and displays the Guest network page badly too [**Image B**]. We can set up a guest network on either the 2.4GHz or 5GHz bands, show or hide the SSID, and opt to add security, or not. Most importantly, there's a checkbox to prevent guest devices from seeing one another or the broader network. For IoT devices, this box should be checked. Note that Google routers don't offer even this level of security, allowing Guest devices to mingle with others.



© ASUS

4 GUEST NETWORKS AND PI-HOLES

If you're using a Pi-Hole to block ads (see November's issue) then you need to allow these Guest devices to access the Pi-Hole, as it's acting as the network's DNS server and therefore the gateway to the wider internet. This comes down to your router firmware. You need to add the IP address of the Pi-Hole, which should be fixed. This isn't an option anywhere in the settings of our Netgear router, and the same is true of a few other brands, including Apple and TP-Link. The only options seem to be hitting the button to allow Guest devices to see one another and the wider network, which defeats the entire point of doing this, or finding some custom router firmware that allows it, and doesn't open a dozen other security holes along the way.

5 VLAN

A Virtual LAN is like a beefed-up Guest Network. Routersecurity.org compares a VLAN to a fish tank. If you have two tanks, the fish in one can't interact with the fish in the other. Put a curtain (or VLAN) between the tanks and they can't even see each other. Misconfiguring a VLAN can mean loss of internet connectivity, many router reboots, and general annoyance to everyone on the network, so go carefully. On our Netgear router, it's the last option in Advanced → Advanced Setup. Put your Ethernet ports and 5GHz Wi-Fi network in one VLAN, and the 2.4GHz network in another. Both can access the internet, but while devices on the 5GHz Wi-Fi and Ethernet can talk to each other, devices on the 2.4GHz wireless can't interact [**Image C**].

ADD A SECOND ROUTER

Putting an old or unused router into your network to gain extra Wi-Fi networks if your main unit doesn't offer more than two is a good way to extend your network, but it's worth making sure that the secondary device isn't too old, as it may then become a security risk in its own right.

To do this, you'll need to put the secondary router into access point mode, which again is something that varies by manufacturer. On our Netgear router, we found it under Advanced → Advanced Setup → Wireless AP, but other models may vary. AP mode switches off the router's modem functions and slaves it to the DHCP service running on your main unit.

It continues to look after the wireless networks it deploys—typically one 2.4GHz and one 5GHz, though you don't have to use both—and routes all traffic through the main router onto the wider network or internet. There are still no options on the stock Netgear firmware to isolate a secondary router from the rest of the network, but you can use a VLAN to separate it off.

Create efficient backups in Linux

YOU'LL NEED THIS

SUITABLE LINUX OS
SSD/HDD with unused space.

MOST BACKUP STRATEGIES lead to a lot of wasted space because you invariably end up making copies of the same data over and over again. In essence, data deduplication is the process of comparing chunks of data that have already been backed up, filtering out duplicated data, and retaining only a single unique copy, thereby saving disk space. When deployed as a data backup strategy, this means that only changes since the last backup are stored.

Backup tools for Linux are as prolific as browsers, video players, or even text editors. BorgBackup, or just Borg, is a deduplicating backup utility—released under the BSD license, the project was forked from Attic, a popular backup utility, in 2015. Thanks to the data deduplication technique, Borg is suitable as an everyday home or even enterprise backup solution, with a host of features that make it a breeze to use. –SHASHANK SHARMA

1 REMOTE STORAGE

Since Borg is only interested in changes since your last backup, the entire process is fast and efficient. Even better, Borg also supports compression, which further limits the amount of disk space taken up by backups. Finally, Borg also supports client-side encryption, so you can safely encrypt backups before they are transmitted to remote storage locations. Apart from all that, Borg backups can be mounted as a file system. This means that you can use a file manager to examine the contents of the backup and restore only specific files.

2 THE BORG ARE GOOD!

No self-respecting Trekkie ever thought of Borg as good, but here at *Maximum PC*, we are pleased to break the mold. You can gauge the popularity of Borg from the fact that it's available in the software repositories of most popular desktop distributions. The project's website, however, cautions that the repositories might not always carry the latest version. Thankfully, the current release, version 1.1.17, is available in most popular distributions such as Fedora, Ubuntu, Debian, Mageia, Arch, openSUSE Tumbleweed, and others.

›› The project's website has a list of distributions and the version in their repositories. Run the `sudo pacman -S borg` command to install BorgBackup on Arch or Mageia. You can similarly run the `dnf install borgbackup` command to install it on Fedora.

›› As expected, the project has a long list of dependencies, so if you decide to compile it from source, please carefully follow the installation instructions on the website. This thorough focus on installation makes Borg one of the best-documented command-line tools we've encountered.

›› The first step is to create a backup repository. You can think of a repository as a file system that's home to all the data you wish to backup. You can place data from different directories into a repository. Borg is able to identify files, even if the names or location changes. For example, if file A in location X is already in the repository, when you attempt to backup file B from location Y Borg uses chunking to determine if file B is indeed a new file.

›› Borg has various sub-commands, such as `create`, `init` and so on, and each has its own set of arguments. Thankfully, you can access help using the `borg command --help` command, or from the website.

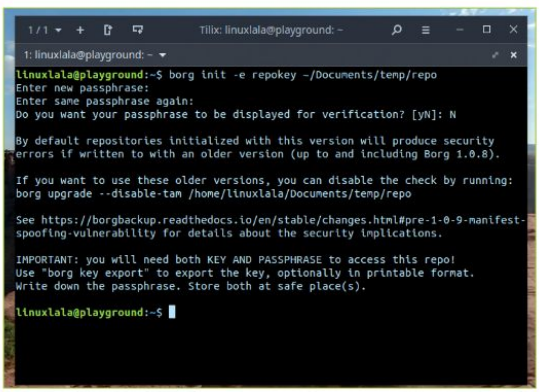
To create a repository, you must run the `borg init PATH` command. The project recommends that you use encryption to safeguard your data. Use the `-e none` option if you don't wish to use encryption. Alternatively, you can choose between using a passphrase only, or passphrase and key encryption.

›› The `borg init -e passkey /path/to/repository` command will prompt you to enter a passphrase. The repository created with the `init` command will be protected by the passphrase. You will not be able to access the repository, add backup files to it, or restore data from it without the passphrase.

3 LEARN TO LIVE WITH THE BORG

Once a repository is created, Borg is now ready to accept files. Each backup is stored in a unique archive within the repository. You can create many repositories and archives with Borg.

›› For instance, you could create a repository to backup PDF files from work, and another repository to backup music sheets. You must use the `borg create /`


1 / 1
Tilix: linuxlala@playground: ~
1: linuxlala@playground: ~
linuxlala@playground:~$ borg init -e repokey ~/Documents/temp/repo
Enter new passphrase:
Enter same passphrase again:
Do you want your passphrase to be displayed for verification? [yN]: N
By default repositories initialized with this version will produce security
errors if written to with an older version (up to and including Borg 1.0.8).
If you want to use these older versions, you can disable the check by running:
borg upgrade --disable-tam /home/linuxlala/Documents/temp/repo
See https://borgbackup.readthedocs.io/en/stable/changes.html#pre-1-0-9-manifest-
spoofing-vulnerability for details about the security implications.
IMPORTANT: you will need both KEY AND PASSPHRASE to access this repo!
Use "borg key export" to export the key, optionally in printable format.
Write down the passphrase. Store both at safe place(s).
linuxlala@playground:~$

›› The borg init command is used to initialize an empty repository. In this example, we've created a repository called repo in the ~/Documents/temp directory.

© BORG

path/to/repo:archive_name /path/to/data command to create a new archive within the repository:

```
$ borg create ~/Documents/temp/repo::first-archive ~/
Documents/LXF-submissions ~/Pictures/for-LXF/
```

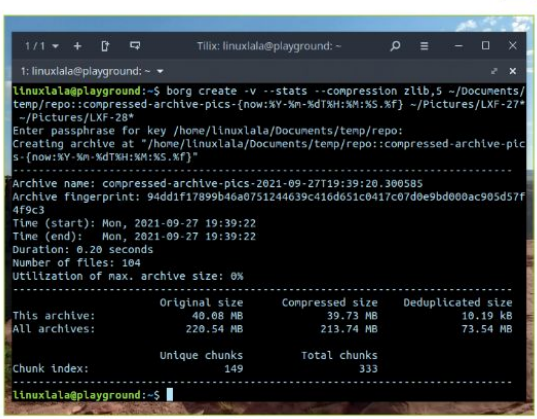
›› In this command, we have created a new archive called first-archive. Borg will recursively traverse through the specified directories and add files to the specified archive. When we create a follow-up archive, only new content from these directories is added to the archive:

```
$ borg create --stats ~/Documents/temp/repo::second-backup ~/
Documents/LXF-submissions ~/Pictures/for-LXF/
Enter passphrase for key /home/linuxlala/Documents/temp/
repo:
Creating archive at "/home/linuxlala/Documents/temp/
repo::second-backup"
------------------------------------------------------------------------------
Archive name: fifth-backup
Archive fingerprint: c4ce413d82e4d00b9b4defdf8eadd
c8af674059a8044aac905e00c527c8224d8
Time (start): Mon, 2021-09-27 18:33:14
Time (end):   Mon, 2021-09-27 18:33:14
Duration: 0.19 seconds
Number of files: 10
Utilization of max. archive size: 0%
------------------------------------------------------------------------------
                       Original      Compressed    Deduplicated
This archive:          35.43 MB      33.91 MB      2.39 kB
All archives:         140.38 MB     134.28 MB     33.80 MB
                   Unique chunks   Total chunks
Chunk index:              38            115
------------------------------------------------------------------------------
```

›› Take a look at the last column in the Deduplicated size. This tells you that the archive only has backed up 2.39K of new data, as all the other data in the specified directories is already part of another archive.

4 MOUNT AND EXTRACT ARCHIVES

As its name suggests, you use the borg extract command to extract data from an archive. By default, Borg will extract the entire content of the specified archive, but you can choose the data you wish to extract using the --exclude option, or even the PATH.


Tilix: linuxlala@playground: ~
1: linuxlala@playground: ~
linuxlala@playground:~$ borg create -v --stats --compression zlib,5 ~/Documents/temp/repo::compressed-archive-pics-{now:%Y-%m-%dT%H:%M:%S.%f} ~/Pictures/LXF-27*
Enter passphrase for key /home/linuxlala/Documents/temp/repo:
Creating archive at "/home/linuxlala/Documents/temp/repo::compressed-archive-pics-{now:%Y-%m-%dT%H:%M:%S.%f}"
Archive name: compressed-archive-pics-2021-09-27T19:39:20.300585
Archive fingerprint: 94dd1f17899b46a0751244639c416d651c0417c07d0e9bd000ac905d57f4f9c3
Time (start): Mon, 2021-09-27 19:39:22
Time (end):   Mon, 2021-09-27 19:39:22
Duration: 0.20 seconds
Number of files: 104
Utilization of max. archive size: 0%
Original size Compressed size Deduplicated size
This archive: 40.08 MB 39.73 MB 10.19 kB
All archives: 220.54 MB 213.74 MB 73.54 MB
Unique chunks Total chunks
Chunk index: 149 333
linuxlala@playground:~$

›› When creating an archive, you can timestamp the archive for smarter filenames. This is more efficient than numbering your backups manually.

COMPRESSED ARCHIVES

When creating a new archive, you can also use the --compression or the -C command option to create a compressed backup archive. Borg defaults to using LZ4, which is fast but offers little compression.

Borg also supports other compression algorithms, such as zstandard, zlib, and lzma. You can use a mix of compression algorithms for different archives within the same repository. This is because deduplication is done on the source data chunks.

With the exception of the default LZ4, all other algorithms expect a compression level. For zstd, the compression levels range from 1-22, while for zlib and lzma, the options are 0-9. borg create --compression lzma,4 repo/path::archive-name data-sources creates an archive using the lzma algorithm.

You can also direct Borg to decide whether the data needs to be compressed or not. This is done with the auto command option. Borg attempts to use the lz4 compression on each file, and should the file be compressive, uses the defined compression algorithm and level:

```
$ borg create --compression auto,lzma,4 repo/
path::archive-name data-sources
```

Borg will first test each file's compressibility using the lz4 algorithm. If the file can be compressed, Borg will compress it using the lzma with level 4.

›› Using our previous example where we created an archive of two directories ~/Documents/LXF-submissions and ~/Pictures/for-LXF/, we can extract all the image files using either pattern matching or the directory path:

```
$ borg extract ~/Documents/temp/repo::first-backup ~/
Pictures/for-LXF
Enter passphrase for key /home/linuxlala/Documents/
temp/repo:
```

›› You can similarly use the --exclude command option to restrict Borg:

```
$ borg extract ~/Documents/temp/repo::fifth-backup
–exclude '*.odt'
Enter passphrase for key /home/linuxlala/Documents/
temp/repo:
```

›› The borg mount command can be used to mount an archive. First, create a mount point for the archive:

```
$ mkdir /tmp/backup
$ borg mount ~/Documents/temp/repo::second-backup /
tmp/backup
```

›› You can now open the /tmp/backup directory in your favorite file manager and look through the contents. Be sure to unmount the archive with the borg umount /tmp/backup command after you're done.

›› You'll also appreciate the borg diff sub-command, which can be used to compare the contents of two archives. The borg diff ~/Documents/temp/repo::second-backup third-backup command will inform you of all the changes between archives.

›› There's much more you can do with this utility. All the information you need to understand Borg's full capabilities is in help pages for each of the sub-commands, or on the project's website.

BUILD IT

ZAK STOREY, EDITOR-IN-CHIEF

Downsizing

Going to a slightly smaller ATX chassis

LENGTH OF TIME: **1-2 HOURS** | LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

THIS LAST BUILD of mine is a bit of a contrarian thing in itself. On the one hand, this is my personal machine. On the other, everything in it belongs to PRs and their respective companies and as such, by the time you read this issue, it will have returned in its entirety to the *Maximum PC* offices.

In many ways, the concept of this build is a moot point. After all, a typical transplant like this is usually undertaken because you intend to use the new chassis for some time, and are curious as to how it performs day-to-day. That said, as PC enthusiasts, as hobbyists, and as journalists, there's a natural curiosity inside us that needs to be sated. It's why we're interested in building PCs to begin with. So, despite the short time I'd have with this build, I knew I had to check it out.

NZXT cases have long been a favorite at *Maximum PC*. The super-clean lines, and design language, combined with a strong price structure have cemented these cases as standout products. The only caveat has been access to cool air. Many years ago, we built an SLI'd system in this case's forefather, the S340 Elite. It was a beast of a machine, beautiful to behold, and powerful beyond all measure. But give it a lengthy session in a graphically intense title, and after an hour or so, the processors started to throttle, and coolant temperature warnings popped up all over the place.

This has been an Achilles heel for NZXT ever since the company reinvented itself with the Manta line of chassis, so to see it ditch the clean smooth panels in favor of a bolder, airflow optimized style with the latest Flow chassis was, er, a breath of fresh air. So then, what's the concept? If we take our personal computer and transplant it from the Corsair 5000D Airflow build, (complete with nine 120mm fans, 360mm premium AIO, and beefy RTX 3080), and move it into the smaller H510 Flow, would the design changes that NZXT implemented be enough to house all that power without throttling under its own heat? Seems simple enough.

CHANGES UPON CHANGES

AT THE HEART OF THIS SYSTEM lies a bit of a Frankenstein build, pieced together out of various parts from several builds that we created throughout the past year or so. The main bulk of that surrounds the Corsair 5000D 4K gaming PC we put together back in March 2021, albeit with a fair few changes on top.

The first big change comes in the form of the GPU. We dropped the AMD Radeon RX 6800 XT for an MSI GeForce RTX 3080 Suprim X. Next up was the memory, we just weren't having any luck with that 32GB (4x 8GB) Corsair Vengeance Pro memory kit, so we swapped it for the special order 64GB (2x 32GB) kit of HyperX Predator DDR4 @ 3200 MT/s that we got in for our tiny NZXT H1 Editing PC back in September 2020. And lastly, we dropped down to a single M.2 drive in the form of the PCIe 3.0 Corsair Force MP400 2TB SSD. By no means a super-speedy drive, compared with the best PCIe 4.0 has to offer, but for our day-to-day use with this machine, it has more than enough storage and performance for everything we do. Aside from that, the motherboard, processor, case, power supply, and cooling were all identical to the 4K system (albeit we did add in one extra sleeved PCIe power cable from a separate Corsair kit for the power-hungry Suprim X GPU).

With all that in mind, and given this was a transplant system, we knew there were going to be some drawbacks when it came to downsizing into the H510 Flow's chassis. Namely the CPU cooler. Because the case only supports up to a 280mm cooler, we ditched the Corsair H150i Elite and instead opted for another Frankenstein part, the be quiet! Silent Loop 2 240mm AIO from our Raijintek Retro build back in our August edition of 2021, all of which would be supported with six of the Corsair QL120 fans from the 4K build to top it off (for maximum internal and external lighting).

INGREDIENTS

PART		STREET PRICE
Case	NZXT H510 Flow	$110
Motherboard	Asus ROG Crosshair VIII Dark Hero	$450
CPU	AMD Ryzen 9 5950X	$740
GPU	MSI GeForce RTX 3080 10GB Suprim X	$2,500
Memory	64GB(2x32GB) HyperX Predator DDR4 @ 3200	$392
PSU	750W Corsair CXF 750W 80+ Bronze	$110
Primary Storage	2TB Corsair MP400 Force PCIe 3.0 M.2 SSD	$370
CPU Cooler	be quiet! Silent Loop 2 240	$140
Fans	6x Corsair iCUE QL120	$233
Operating System	Windows 10 Home 64-bit OEM	$32
Total		$5,077

1 DECONSTRUCTION

THE 5000D AIRFLOW has been a fantastic choice for a chassis for this 4K build. Its only drawback (as long-time readers will know, we tend to lean on the smaller side of PC building life) is that it's a big, solid unit. Now that could be a positive, it certainly makes it easier to build in and easier to cool, but as our systems are typically something we want to show off, it's less than convenient placing it on a desk.

Thus the conundrum. Ours has sat underneath a 9ft long desk for well over half a year at this point, where it's just sucking up dog hair and dust perpetually. So removing all of the kit and migrating it into a smaller chassis that we can stick on top of the desk, without it looking too out of place, is the perfect call.

2 FRANKENSTEIN'S MONSTER

A LOT OF DIFFERENT PARTS are going into this build from the original setup, but the one thing we can't take across is the cooling. Sadly, the H510 tops out at a single 280mm AIO and, as such, we need to pick out a new cooler.

We decided on the Silent Loop 2 for a number of reasons. It's really easy to install on an AMD socket. The pump is insanely quiet, and honestly, we quite like the design. One thing we won't be taking with us is the two be quiet! fans. Instead, we'll be using the Corsair QL fans that we built with during the 4K build, but doubling up, and attempting to configure a push-pull configuration (basically having two fans on one side pushing air through the radiator, and another two on the opposite side pulling), but more on that later.

3 WHY NO AMD GPU?

SO WHY DID WE SWAP from the RX 6800 XT? For convenience, mainly. The card was needed for another build later in the year, and so we pulled it out on the day of the shoot, went into the office, built a machine with it (the G.Skill Z5i system), and then grabbed a replacement card to fit in the PC at home, while the Z5i was being tested with the 6800 XT. It really is that simple. Such is the life of a tech journo, perpetually swapping parts.

Performance deltas between the two are fairly negligible, some games are better optimized to AMD (eg. *Assassins Creed: Valhalla*), others are better suited to Nvidia (any with ray tracing). One thing we would point out is that the Suprim X is massive and requires three 8-pin PCIe power cables as standard. We will run into problems with this later down the line, too.

4 GO WITH THE FLOW

NZXT'S FLOW IS perhaps the best implementation of an airflow style chassis we've seen to date. At least from a style perspective, anyway. Those front perforations are large, impressive, and it's super-slick and super-clean. You still have the square panels, tempered glass, PSU covers, cable tidies, and everything you'd find in a standard 510, but without the solid front panel.

The front panel itself is a bit more solid than the Corsair case we used for the build-off in the previous issue, and it has a fairly fine dust filter magnetized into the front of it. You can remove it for cleaning, but it is a bit of a tight fit in the panel itself and can be a bit troublesome to get back in once you have cleaned it.

Once the fans are installed, there is about an inch of space between the fans and the front filter too.

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5 LIGHT SHOW

THIS IS ONE OF THOSE form-over-function choices we often have to make here at *Maximum PC*. Let's be clear, these are awesome fans with some seriously cool lighting effects, but they aren't entirely the best at cooling radiators. You know how some people buy cars with large V8 engines that sound great but aren't particularly fuel efficient? It's a bit like that. We know they look awesome and that they will fit the build well, but they're no Noctuas, that's for certain.

For stats, they pump out a fairly reasonable pressure of 1.55 mmH2O and can shift just under 42cfm of air too. They're not cheap either, with a triple pack setting you back $116. For that, you get the three fans plus a separate RGB controller (although we're cannibalizing something for that a little later). Ouch!

6 PANEL REMOVAL

NOW WE'VE GOT all the parts removed (and well showcased), it's time to get stripping this thing down ready for the build. The H510 Flow is a fairly easy case to take apart and the front panel pops off easily. Pull it from the rear side of the case and the two pins will pop out from the top, you can then lean it back and pull it out.

The tempered glass side panel is also fairly minimal in design. A single thumbscrew holds it in place at the top left of the panel. Undo that, then lean the window out towards you and lift out.

You will also notice that there's a radiator bracket in the front of the chassis there. You can remove this with two thumbscrews, however, we're leaving it in for the time being.

7 HDD CAGE REMOVAL

TO GIVE OURSELVES a bit more space in the bottom of the chassis to allow for some cable stuffing. We're going to remove the 2.5-inch/3.5-inch hard drive caddy. To do this, we pop the case on its head to allow us complete access to the bottom of it. Here, you will notice four Phillips screws securing the caddy in place.

Simply remove these four screws, and then carefully remove the cage from the side of the chassis. Just make sure the rear panel is off first and that you have a hand underneath when removing the cage so that it doesn't just drop and start rattling around the case.

8 MOTHERBOARD INSTALL

WITH THE CAGE REMOVED, we have taken the opportunity to remove the front radiator bracket and also the rear-most fan from the case. Every fan-mounting location we have here is going to be filled with a fan.

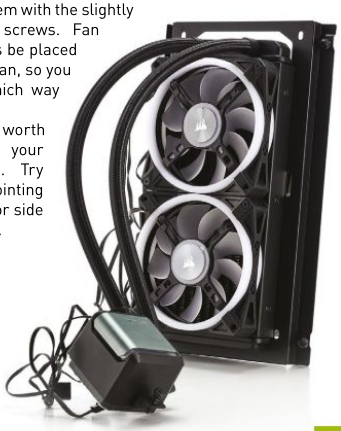
As we're just transplanting this rig, there's not much in the way of legwork that needs to be done before installing the motherboard. The AMD processor is still installed in its socket, and the M.2 SSD is tucked away, hidden beneath its bottom-most heatsink. Line the board up, slot it in place, and secure it with the screws provided in the chassis accessory box.

9 FAN CABLE NIGHTMARES

NEXT UP on the list is preparing the cooler for installation. As we're going to attempt to run push-pull with our configuration, we need to effectively pin the radiator to the bracket using the front intake fans. Place the fans on the outside of the bracket and the radiator on the inside, then use the slightly longer screws provided with the cooler to secure it in position from one side.

With one side complete, move on to the rear pulling fans and install them with the slightly shorter radiator screws. Fan guards will always be placed at the rear of the fan, so you can easily tell which way the air will flow.

It's also worth keeping in mind your cable orientation. Try and keep them pointing towards the rear or side panel of your case.



10 CABLE BAR FAILURES

AS PUSH-PULL is a fairly rare concept these days for AIO coolers, most manufacturers don't allow that much clearance for it in small footprint case designs like the H510 Flow. As such, with this neat cable bar installed, you can't install the radiator with fans in this configuration without conflicting with the cable bar. The only solution is to remove the cable bar, then install the radiator first.

However, after trying this, the cable bar still didn't fit in place, so we removed it entirely. Removing it is a fairly easy process. Simply locate its connection points on the rear of the chassis and remove the four Phillips head screws that are holding it in place.

13 CORSAIR COMMAND MODULE

EACH OF THE FANS in this build has two cables apiece—one for the fan control and the other for RGB control. On top of that, we also have one cable for the pump control. To get around this, we're pilfering the Corsair Commander unit from the 5000D build and repurposing it for this rig. It still has a bit of stick left in its double-sided tape and so that helps us organize all our fans neatly into position, sorting all six.

This is then powered by a single SATA power header and plugs in via USB to the motherboard. We're then free to install the be quiet! pump cables where they need to go. There's one dRGB header at the top of the motherboard and the pump's fan control will go directly into a PWM header also located at the top.

14 SUPRIM-LY OVERSIZED

THERE'S NOTHING LIKE coming up against a problem and finding a solution. At first glance, when looking at the ridiculously long Suprim X RTX 3080 from MSI (13.2-inches or 336mm), it looked like it would just about fit in the case, with the radiator and fans running in push-pull. Looking at how the card mounted in its PCIe slot, it seemed clear that it would fit, albeit snugly.

On the first attempt it didn't, so we removed the radiator and tried fitting it first, then sliding in the radiator. Still no luck. We installed the radiator back in place and removed the bottom-most fan, intending to reinstall it later. On this attempt, we just managed it but it led to us using a tri-fan push-pull setup, rather than the full quad. Annoying! We'll save our thoughts on that for later.

11 CPU BLOCK ATTACHED

WITH THE RADIATOR INSTALLED and the fan cables threaded through into the rear of the chassis, it's time to install the block onto the processor. Luckily, as we used this cooler in our Raijintek build (also an AMD system), we had all the mounting hardware to hand.

Installation is simple enough. There are four plastic standoffs, two metal brackets, and four screws. Remove half the stock mounting bracket that comes with the board and install the be quiet! one over the top. Once secure, do the same with the top. This is a smart way to reduce fiddling about with the back bracket when the board is already in the case. That way it won't fall out, unlike if you removed both stock brackets at once.

12 CABLES, CABLES, CABLES

WE KNEW THIS was immediately going to start getting a little cramped in here. So cables were next on the agenda. The two CPU power cables went in at the top left, then the motherboard's 24-pin, and the front panel connectors went in the bottom. We then installed the remaining fans in position making sure to route everything to the back of the chassis for our secret weapon.

Fitting to the top-most fan was a bit of a pain because, even though it was slightly smaller (120mm not the maximum supported 140mm), it was making contact with that right-most CPU power. After some 'gentle' encouragement (including pushing it in place really hard), finally, we managed to get it secured.

15 STOP SAGGING

THIS IS ONE OF the neat things about this case. Given the hefty girth of the card, it has a tendency to sag. The RTX 3000 series are seriously hot and so most of the cards' cooling solutions have been amped up to be a minimum tri-slot design. The Suprim X is no different in that regard. Because that puts an excessive amount of weight on the slot, you can end up with GPU sag, so to combat that, MSI includes this handy little adjustable stand.

Usually, these stands look really out of place and a bit ugly, but given how close to the radiator that GPU is, you can almost hide this alongside the AIO. That should reduce tension on that slot and keep our card more secure in the long term.

16 COMPLETED!

WITH THE GPU FINALLY IN and the card plugged in, the system was complete, but not quite as bright as it should be. Despite having iCUE all preconfigured, thanks to a pre-installed OS (as it's a transplant system), it wouldn't load the settings and defaulted to this until a complete reinstall was performed. Why? Not a clue. Most likely it's something to do with unplugging everything from the Corsair Commander module and removing the iCUE cooler extension. This thing looks epic. Of course, it's not without its flaws but, then, no build ever is.

DISCOVER THE ALTERNATIVE TO APPLE AND WINDOWS

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FUTURE

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1 **We've adjusted this adjustable bracket a little bit too high, so it's putting too much pressure on the GPU, and making the bar lean inwards, annoyingly.**

2 **Moving the radiator to the outside of the bracket may allow us to install that missing fan here instead.**

3 **White cables would help better reflect our light choice on the RGB setup. Neutral tones help a lot with lighting.**

HA DET BRA!

YOU KNOW, as a final build, in a chassis that we didn't originally plan to build in (the latest Bitfenix Prodigy was ordered, but won't arrive until next month), this turned out to be a really fun exercise.

We've been using this rig for a few days and it's a smooth-running piece of kit. Let's talk performance because that addresses some of the pitfalls with the build process and more. The big one is the temperature. Does the H510 Flow have enough grunt in it to keep our RTX 3080 Suprim X and 5950X 16 core processor cool? Short answer: yes.

We've been doing some lengthy *Middle Earth: Shadow of War* playthroughs lately, keeping an eye on HWMonitor as we do to track GPU and CPU temperatures, and neither seems to go above 80°C at all. Now, admittedly, the card does top out at 83°C in its BIOS settings anyway, but we're nowhere near that and the CPU is pretty cozy too. There are no temperature warnings or anything of that ilk. It's a well-cooled case, and using all of the possible fan mounting locations has helped that. One thing to note, though, is that the top of the chassis gets hot—like, can't put your hand on it hot—after four hours of continuous use or so.

Aside from that, performance is as apocryphal as it always has been with this kind of combo. CineBench R15 scored a seriously impressive 4,299 in multi-core, and 262 in single-core performance, our SSD topped out at 3,114 MB/s read and 2,938 MB/s write, and well, the RTX 3080, did what RTX 3080s do at 4K. Munched frames.

With that out of the way, there are a few post-build thoughts that have crossed my mind, particularly with the GPU situation and that missing fan. There may be two ways of remedying this, which we didn't perform on the day. First, we could have made better choices with our GPU. If we had gone with the RX 6800 XT, which measures just 267mm or 10.5-inches, it's a full 2.7-inches shorter than the Suprim X. Swapping that out would have allowed us to install the additional fan.

If you don't want to give up the RTX 3080, another solution might have been to mount the entire radiator unit to the exterior of the radiator bracket. There's a good inch or so between the front intake fans and that fan filter on the front grill. Shift the entire unit so the radiator and intake fans are on the outside of the bracket and the pulling fans are on the inside, and you'd gain the clearance necessary to fit the card.

That said, it's still a sweet build. A sad reminder of what you could build if the industry wasn't currently messed up (read our review of the H510 Flow on page 82).

Alas, this is where we say goodbye. Whoever you are, no matter what your age, when it comes to picking your next PC, I implore you to build your own. Yes, it can be frustrating and occasionally difficult, but it's such a satisfying thing to do and well worth it, in my humble opinion.

BENCHMARKS

	ZERO-POINT	
CineBench R15 Multi (Index)	4,278	4,299 (0%)
CrystalDisk QD32 Sequential Read (MB/s)	4,985	3,114 (-38%)
CrystalDisk QD32 Sequential Write (MB/s)	4,199	2,938 (-30%)
Total War: Warhammer II (fps)	65	73 (12%)
Shadow of the Tomb Raider (fps)	80	86 (8%)
Red Dead Redemption II (fps)	69	77 (12%)
Middle Earth: Shadow of War (fps)	72	79 (10%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero point consists of an AMD Ryzen 7 5950X, 32GB of DDR4 @ 3600, an AMD Radeon RX 6800 XT, and a 1TB Corsair Force MP600 PCIe 4.0 M.2 SSD. All tests were performed at 4K on the highest graphical profile available.

LAB NOTES

ZAK STOREY, EDITOR-IN-CHIEF

Thankyou & Goodbye

It's been a hell of a ride

Where it all began

MAN, THIS HAS BEEN a really difficult issue for me to write. On the one hand, and I'm sure my production team will agree, I've been insanely efficient for once, meeting every single one of my personal deadlines ahead of schedule, planning, commissioning, and organizing the next two issues on top of that, so my successor doesn't have such a hard time, and generally just being punctual with backup plans on backup plans.

But on the other hand, it's been difficult because it's going to be my last issue. I'm finding it challenging at times to write, without getting emotional. It's in the back of my mind that this is my last build-it, my last review, my last editor's intro, and that's quite rough. For me at least.

I know that might sound ridiculous, but it's just one of those things. *Maximum PC* has been pretty much the entirety of my working career to this point (aside from a stint on *Tom's Hardware*). It's where I became the man I am today. It has allowed me to do so many things, learn so much, and hone my craft. It has massively contributed to my next career move too.

Without it, I would likely have broken up with my partner that I met at college years ago, due to long distance. I wouldn't have my house, my dog, and I'd probably be living back home, working in the police or as a construction worker like my old pops and grandfather before him. And that's not even mentioning all the incredible people I've had the opportunity to work with, the friendships I've made, and of course interacting with all of you, which has been incredibly special to me.

I've nothing but good things to say about the magazine and its community. I'm so thankful for all of the support, particularly over the last couple of years. I have loved reading all of your letters and emails—I know I didn't respond to everything, but I did read all of them and tried to bear your suggestions in mind whenever I could.

The reason *Maximum PC* still exists today is because of all of you, without a shadow of a doubt. Without your support, we couldn't do what we do and, yeah, that just makes it something special. So thank you for everything. It's been a pleasure and absolute honor being editor of this place. It's a time in my life I won't forget.

So for now, I'll sign off for one last time. I wish you all the best, and if you ever see me and my flat cap out and about, let me know and I'll buy you a beer!

SAM LEWIS

Staff Writer

As you can imagine, the pandemic has well and truly put a stop to press events. The chance to travel the world to be among the first to hear about the latest tech is a privilege and it was certainly a huge incentive to join the industry. However, I started slap-bang in the middle of Covid-19, so until now I haven't been able to go anywhere.

Thankfully, I was able to go to Intel's Alder Lake CPU event in late October to learn about the new 12th-gen chips. This is one of Intel's biggest architectural changes in a decade and I have to say I'm excited about the full release. I won't give away too much here, but if you're into overclocking, you should be excited about these new processors. They make the experience much easier with far more customization than before. We'll also see Intel's XMP 3.0 supporting DDR5 memory too. Exciting stuff.

One of the biggest leaps forward is the introduction of a hybrid architecture. These processors now contain both performance cores for foreground tasks and efficient cores for background tasks. They also have Intel's Thread Director to dictate which cores do which job for maximum performance and efficiency, but more on that next issue.

Although the gathering was a lot smaller than typical press events, I had a great day meeting lots of new people and getting a taste of what's to come (hopefully) in the future.

Editor's Pick:

Nighthawk 5G WiFi 6 Mobile Hotspot Pro

Aside from the crazy name, this is pretty cool

LONG AGO, before I first left *Maximum PC*, I looked at Netgear's portable 4G mobile modem/hotspot. That thing was awesome—if you couldn't get a decent internet speed from the local Wi-Fi or your ISP, you'd simply pop in a sim for an easy and convenient way to get running at 4G speeds.

When I left the mag, I actually pinched it from Alan, much to his disdain. The reason was that, before I moved to *Tom's Hardware* in January 2019, I bought my first home, and boy did it need some work. It's fine, I'm a bricklayer's son, so working around building sites is sort of my thing. The problem was, the internet at the time was a mess and I had to wait two months to be connected. The house was out in the sticks, so there was a chance the network could go down if we had a bad storm. I was nervous, especially approaching my first day at the new job, and it being the start of CES. So I grabbed the Nighthawk M1 4G, popped my sim in, and was good to go.

Since then, it's been all over the world with me, from London to Singapore to Taiwan to New Zealand. It's just a handy device that gives me the freedom of a solid connection for my laptop, without having to go through a dodgy local Wi-Fi or worse.

So, when Netgear said it was releasing the next generation of Nighthawk hotspot modem, my interest was piqued once more. Of course, this uses the 5G standard and, as I've just upgraded to the S21 Ultra, it looked like an intriguing thing to review.

On the surface, it is an incredible device. It's an SFF router complete with WiFi 6 for up to 32 devices. It comes with a 13-hour battery life as standard but you can plug it into a wall, like the last-gen version, and, perhaps unsurprisingly given our previous review, you can control it via the app.

The touchscreen display tells you your bandwidth limits, the network's name, and the Wi-Fi password, along with battery and network stats at a glance, and it packs a ton of security on top. Heck, it even comes with a gigabit ethernet port and USB Type-C port too.

However, I have two problems with it. Firstly, the price. Oh boy, is it expensive. To put it into context, the original 4G version I used came in at $350. That's a lot of cash, but not unreasonable, and if you're on the go and need a secure network, it's an expense you can justify. But the 5G version costs $700! There's a lot of new tech and features here, but seriously? Double the price?! That is, of course, an unlocked variant. I have been told you can pick these up with service providers as well, locked, for far cheaper on contract, but even so.

My second problem, perhaps a bit more obscure, is with 5G. It's not what you think, though. My issue with 5G is how poor the signal strength can be. As a connection standard, it's not very good. I've read numerous reports of devices requiring a direct line of sight to a 5G antenna to get full speeds and even a report from one meteorological service saying that raindrops can block 5G signals. Raindrops! I live in a wet part of the world already, but one day, I want to move to Bergen in Norway, where it rains 239 days a year. That limits 5G to sidewalks and roads, meaning this device might not be worth it compared to the 4G version I already have.

That's a shame because, on paper, it's a fantastic piece of kit—a compact WiFi 6 router with top-notch speeds. If you live in wetter climes, you should consider grabbing its older sibling instead **–ZS**

$700, www.netgear.com

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92 Far Cry 6

Review courtesy of PC Gamer, read the full review here: https://bit.ly/PCGIntel12

Intel Core i9-12900K

Finally, Team Blue's Hybrid 10nm design is here

ALDER LAKE is Intel's first desktop processor to use the Intel 7 process node, which was previously referred to as Intel 10nm SuperFin, and also the first in a long time to not use the 14nm process node.

Oh, how times have changed. Intel has finally broken free from the shackles of 14nm and managed to escape the node that was once so congested it caused an embarrassing pile-up for the chipmaker. With Alder Lake, Intel is no longer tied to that node and so it is free to do more in the space it does have. The company says it even expects to shift plenty of Alder Lake chips this side of New Year. So, perhaps this is some silicon you will actually be able to buy at launch.

The most notable change of all for Intel Alder Lake, though, is the hybrid Core architecture. What this means is that Intel is stuffing all of the K-series 12th-Generation chips, those that are arriving at launch, with two types of cores: Performance Cores (P-Cores) and Efficient Cores (E-Cores).

The P-Cores are based on the Golden Cove micro-architecture, which is one step beyond the Willow Lake micro-architecture found in Intel's 11th-gen mobile Tiger Lake processors. Alder Lake's P-Cores are more closely related to the CPU cores of previous Intel desktop generations. Take the Core i9 10900K, for example, which has eight CPU cores in total. Consider the 12900K's eight P-Cores in much the same way, although considerably faster.

For gaming these P-Cores are key. They offer the highest clock speeds of the two—on the Core i9 12900K, these reach 5.2GHz at times—and nail down slick single-threaded speed for it. They're also built to minimize latency, and they're technically wider and smarter to catch up with the competition.

Each P-Core has access to 1.25MB of L2 cache. From there, they're hooked up to 30MB of Intel Smart Cache, which is shared between E-Cores and onboard integrated graphics, though that is disabled in the KF-series chips. For a marker of performance, the Core i9 12900K's P-Cores are able to surpass the Cypress Cove cores in the Core i9 11900K by a significant margin, and we're yet to touch on the eight Efficient Cores Intel has stuffed into the 12900K's back pocket.

Intel has been talking a good game when it comes to Alder Lake performance, and after getting our hands on the Core i9 12900K, we can't say we're surprised, either. This chip does reclaim the gaming performance crown in almost every game we tested, and often by quite some large margin.

The same goes for synthetic single-core performance. We ran Cinebench R23 through a 10-minute cycle to ensure no power draw funny business, and the Core i9 12900K delivered a tremendous leap in single-core performance over the best of Zen 3 in the Ryzen 9 5950X. Even the lower-clocked Core i5 12600K delivers a huge bump here.

When it comes to CPU power and thermal performance, Intel has clearly still had to push its Core i9 package to make sure it is capable of beating AMD's top Ryzen processor. That means a much higher power draw under load than AMD's Ryzen 9 5950X during x264 v5.0 benchmarking, at a 53 percent increase, and a 6°C increase in peak temperature.

That's even in excess of the Core i9 11900K, the chip infamous for its high wattage draw. Though Intel writes this off by saying that if you were to drop the Core i9 12900K to even a fraction of its 241W MTP, at just 65W, it would still be a match for the Core i9 11900K. At least the performance is there to justify the leap in wattage in comparison with Intel's own chips, but next to AMD's processors, it still appears comparatively high.

From an enthusiast's point of view—and the Core i9 12900K is an enthusiast chip after all—this chip totally obliterates previous Intel generations by most metrics: single-threaded performance, multi-threaded performance, clock speed, and memory performance. And you're probably paying less for the privilege, which is saying something in this day and age. **–JACOB RIDLEY**

VERDICT **9**

Intel Core i9-12900K

+ PIERCING THE HEAVENS Incredible single-core performance; huge multi-thread performance; big leap for Intel; DDR5 and PCIe 5.0 support.

– PLUMBING THE DEPTHS Some games don't play nicely; high power consumption; new platform costs.

$590, www.intel.com

BENCHMARKS

	Intel Core i9-12900K	AMD Ryzen 9 5950X
CineBench R23 Single (Index)	**1,886**	1,617
CineBench R23 Multi (Index)	**26,434**	24,109
Tech ARP's x264 (avg fps)	76	**81**
Total War: Three Kingdoms (DX11) @ 1080p	**211**	196
Far Cry 6 (DX12) @ 1080p (avg fps)	**147**	136
3D Mark: Timespy CPU Score	**16,240**	12,554
Recommended Retail Price ($)	**$590**	$750

Best scores in bold. Test bed consists of an Asus ROG Maximus Z690 Hero, 32GB (2x16GB) Corsair Dominator Platinum RGB DDR5 @ 5,200 MT/s, an Nvidia GeForce RTX 3080, 1TB WD Black SN850 PCIe 4.0 SSD, and an NZXT 850W PSU. All tests performed on Windows 11 on the highest preset available.

SPECIFICATIONS

Cores/Threads	8/16 P + 8/8 E
Base/Turbo Clock	2.4 / 5.2GHz
Architecture	Alder Lake
Lithography	Intel 7 (10nm SuperFin)
Memory Support	DDR5 @ 128GB (4800MT/s) / DDR4 @ 128GB (3200MT/s)
PCIe Support	PCIe 5.0 x16 (Graphics), PCIe 4.0 x4 (Storage)
Integrated Graphics	Intel UHD Graphics 770
TDP	125-241W

XFX Radeon RX 6600 Speedster SWFT 210

Not the fastest card on the block

AMD'S RX 6600 GPU may be the end of the line for desktop RDNA2 graphics cards. AMD also has APUs with RDNA2 graphics in the works, and Samsung's upcoming Exynos smartphone chip will put RDNA2 into mobile devices. We'd be hard-pressed to name one good reason why a smartphone needs ray tracing hardware, but that's a topic for another day.

Building off the same Navi 23 GPU that powers the RX 6600 XT, the vanilla 6600 comes with 28 of the potential 32 CUs enabled. That's a relatively small reduction in the number of functional units, but AMD also trims clocks by anywhere from 100–300 MHz, depending on GPU temperatures, power use, and other factors. The GDDR6 memory also gets a speed reduction from 16Gbps down to 14Gbps.

Taken as a whole, the RX 6600 should in theory be anywhere from 10 to 25 percent slower than the RX 6600 XT. In practice, our testing shows an average drop in performance of 13 percent at 1080p and 15 percent at 1440p. The official launch price is also about 14 percent lower, which would be great if you could find the cards in stock for anything close to the official MSRP. You can't, and in fact, the cards are already selling for an average price of $560 on eBay. Feel free to insert your own swear words here.

Ignoring street prices, which are messed up across the entire graphics cards spectrum right now, the RX 6600 delivers mixed results. Some games such as *Assassin's Creed Valhalla* and *Borderlands 3* perform quite well. Games with more complex ray-tracing engines such as *Control* and *Cyberpunk 2077* fall flat. We're not particularly surprised by the results in DXR games, but it does feel more like a feature checkbox rather than something people will be able to use, especially with games that will only get more complex rendering engines.

The primary competition for the RX 6600 comes from Nvidia's RTX 3060, and despite XFX calling this card the Speedster SWFT, it's neither of those things. It beats Nvidia in the AMD promoted games by about 10 to 15 percent, but overall ended up being about 10 percent slower. Nvidia also gives you 12GB of GDDR6 memory, a rare case for this generation of cards as elsewhere AMD usually provides more VRAM. When we factor in DLSS and Nvidia Broadcast, the RTX 3060 ends up the superior card.

AMD's newcomer does have some other selling points, though. Its official TDP is only 132W, which means it could have theoretically worked with a single 6-pin power connector, but XFX went with an 8-pin adapter. It didn't prove much in the way of overclocking headroom, but 8-pin connectors are becoming ubiquitous these days. Our power testing confirmed that the card mostly adheres to that power limit. We measured 140W in FurMark and 137W while gaming, but we won't lose sleep over an 8W difference.

If you're after a compact card that can work in a mini-ITX case or a home theater PC, the RX 6600 is worthy of consideration. It's interesting that overall performance at 1080p and 1440p was about five percent faster than AMD's old RX Vega 64 while using less than half the power. Still, it's difficult to get excited about a card that delivers a performance that has been available for five years—the GTX 1080 also comes pretty close to the RX 6600 in performance, as does the previous generation RX 5600 XT.

Sadly, this isn't the classic story of the tortoise and the hare. The RX 6600 starts off sluggish and never really closes the gap to the more desirable cards. If you can find one for close to the $330 price, it's worth getting, but be prepared to keep to the right lanes while the real speedsters zip past in the fast lane. –JARRED WALTON

BENCHMARKS

	XFX Radeon RX 6600 SWFT 210	AMD Radeon RX 6600 XT	Nvidia GeForce RTX 3060
8 Game Average (afps)	55 / 35	**63** / 41	**63** / **47**
Assassin's Creed Valhalla (afps)	72 / 52	**87** / **63**	65 / 50
Borderlands 3 (afps)	88 / 58	**107** / **70**	77 / 55
Control (DXR)	30 / 17	34 / 19	**47** / **29**
Cyberpunk 2077 (DXR)	16 / 5	16 / 6	**31** / **19**
Dirt 5 (afps)	82 / 66	**94** / **72**	80 / 63
Horizon Zero Dawn (afps)	83 / 62	**98** / 72	96 / **76**
Metro Exodus (afps)	63 / 47	**74** / **57**	65 / 52
Red Dead Redemption 2 (afps)	62 / 48	**70** / **57**	**70** / **57**

Benchmarks at 1080p / 1440p Ultra, best scores are in bold. All testing conducted with a Core i9-9900K, MSI MEG Z390 ACE, 2x16GB DDR4-3600 CL16, 2TB XPG 8200 Pro M.2 SSD, Thermaltake Toughpower GF1 1000W. Scores are average framerates at the indicated resolutions.

VERDICT **7**

XFX Radeon RX 6600 Speedster SWFT 210

➕ **SPEED DEMON** Efficient architecture; compact design; single 8-pin power.

➖ **SLOW SNAIL** Deep cuts; weak RT; high street prices.

$330, www.xfxforce.com

SPECIFICATIONS

Architecture	Navi 23
Lithography	TSMC N7
Boost Clock	2,491MHz
GPU Cores	1,792
Memory	8GB GDDR6 14Gbps
TFLOPS FP32	8.9
Bandwidth	224GBps
TDP	132W
Connectors	1x HDMI 2.1,3x DisplayPort 1.4

XFX's compact RX 6600 card has a performance roughly equal to the Vega 64 while using half the power.

MSI GE76 Raider

Strong, sharp, and bulky. This is no shy beast.

THE PREVIOUS FEW MSI laptops we've reviewed have been pretty decent but were generally located around the budget to mid-range sector of the market. However, this offering from MSI is quite the opposite. With the GE76 Raider, everything is on the larger side, including its price tag of over $3000. The 17-inch format doesn't exactly make for the most nimble of devices either. Though it's aimed at a fairly specific gamer target market, a laptop of this size loses the benefit of portability. So then, is this machine worth your time and money, and could you use it as a desktop?

Compared with the most recent MSI laptops, you get a feel of why this beast is almost double the price of those models. This is a large and solid bit of kit with no screen wobble thanks to its weight. Even if you have a rucksack that can fit this in, you better have the energy and strength to carry it around. It's a big old thing, but not quite as brutish as Gigabyte's Aorus 17 we looked at earlier this year.

The titanium blue lid gives it a nice premium color and with MSI's crest sitting in the middle, it's far from an eyesore. There's a funky RGB light bar to the bottom of the laptop, which adds a nice touch to your setup. It's not a typical LED strip, more a block of RGB that fits the shape of the laptop. When the lid is down or the RGB is turned off, you can't even tell that it's there. The flip side is that it's not exactly the best thing for the battery life. Though the GE76 Raider 11UH has a huge 99.9 Whr battery, with this much power and a 17-inch screen, our advice is to keep it plugged in.

Continuing with the hardware side, it hosts a 17.3-inch 360Hz panel at 1080p resolution. Other variations offer a higher resolution screen but the compromise is that you can't get a 360Hz refresh rate on those displays. The variation we have here is all about performance—1080p gaming on a screen of this size is pretty good, especially with that nippy 360Hz. Sure, this FHD display isn't the crispest nor the brightest, but it still delivers a good performance. If you are more interested in pixels than frames, your best bet is probably the UHD 3840x2160 model, which still runs at a solid 120Hz.

The keyboard on this laptop is pretty decent, despite featuring MSI's font. The keys are soft but still tactile enough to give you good feedback, and they have a nice deep travel too. Of course, they are individually backlit to match the RGB light bar at the front. This is all controlled in the SteelSeries GG application.

The mechanical keyboard on the Gigabyte Aorus still is the best we have used on a 17-inch laptop and, unfortunately, this isn't quite on that level. The trackpad isn't the greatest either, but it's decent enough for procrastination. However, we feel that for the size of this laptop it could have been a bit larger. It's a bit off-centered too, which is good for right-handed people as you have plenty of space to rest your wrist. Of course, that's not so good for the lefties out there.

Where this laptop really shines is in its performance. The unlocked Intel i9-11980HK is a monster chip, being one of the fastest laptop chips around, especially working in conjunction with the RTX 3080 inside. It blitzed our benchmarking scores and you won't be disappointed with gaming on this laptop. With 64GB of RAM too, you can chuck almost anything at it. For a desk or table setup, it's a great size too but if you wanted, you can easily hook it up to a monitor and still get very impressive frames. This is one behemoth machine, there is no denying that.

With its 17-inch screen, this MSI model has more of a niche target market than many other gaming laptops. If you don't have a desktop PC, and still want to game to a high quality and take it around with you on occasion, you can connect it to a monitor and still have some degree of portability. It has plenty of connectivity and ports too, a snappy display, and an almighty lighting performance for productivity and gaming. However, you'll have to put up with the noise of the fans when gaming, the heftiness of it when carrying it around, and the poor battery life when on the go. **–SAM LEWIS**

VERDICT 9

MSI GE76 Raider 11UH

TOMB RAIDER Blistering performance, solid build, super nippy 360 Hz display, decent keyboard, loud speakers..

TOMB RAIDED 360 Hz only offered at 1080p, loud fans, pricey, poor portability.

$3,399, www.msi.com

GAMING LAPTOPS BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,137	1,415 (-34%)
CrystalDisk QD32T1 Sequential Read (MB/s)	3,595	6,781 (89%)
CrystalDisk QD32T1 Sequential Write (MB/s)	3,107	4,968 (60%)
3DMark: Fire Strike (Index)	20,529	22,591 (10%)
Rise of the Tomb Raider (fps)	107	158 (48%)
Total War: Warhammer II (fps)	62	122 (47%)
Tom Clancy's Ghost Recon: Wildlands (fps)	61	77 (26%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the ASUS ROG Zephyrus G15, with an AMD Ryzen 9 5900HS, Nvidia GeForce RTX 3080 and 32GB of DDR4-3200. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	Intel i9-11980HK
Graphics	NVIDIA GeForce RTX 3080 GDDR6 16GB
RAM	64GB DDR4 3200MHz
Screen	17" 1080p @ 360 Hz
Storage	2TB NVME M.2 SSD
Ports	2x Type-A USB 3.2 Gen1, 1x Type-A USB 3.2 Gen2, 1x Type-C USB 3.2 Gen2, 1x Type-C (USB/DP/ Thunderbolt 4), 1x RJ45 Ethernet, 1x SD Express, 1x Mini-DisplayPort, 1x (8K @ 60Hz / 4K @ 120Hz) HDMI
Connectivity	Killer ax Wi-Fi 6E + Bluetooth v5.2, Killer Gb LAN (Up to 2.5G)
Weight	6.3lbs
Size	1 x 11.1 x 15.6 inches

Lurking under the cover of this beast, there is tons of power.

Monoprice's latest 27-inch 1440p gaming panel packs a mega feature set for the money.

Monoprice Dark Matter 27-inch IGZO 180Hz Gaming Monitor

Getting more gaming monitor for your money

FROM THE SUBLIME to the ridiculous, this month's 1440p gaming monitor pairing has it all—we're just not sure which is which. Where the Corsair Xeneon 32QHD165 bumps right up against the limits of what seems plausible for a 'mere' 1440p panel at this price, the Monoprice Dark Matter 27-inch IGZO 180Hz Gaming Monitor comes at it from the opposite angle. This thing is cheap.

For just under $350, Monoprice offers a 27-inch gaming monitor based on a cutting-edge IGZO-type IPS panel, complete with 180Hz refresh, adaptive sync, and HDR 400. You even get USB Type-C connectivity with power delivery for charging a laptop. That's one heck of a spec list for the money. It really is.

Drilling down deeper into the speeds and feeds, the 'IGZO' panel tech refers to the use of Indium Gallium Zinc Oxide, rather than the more common Amorphous Silicon semiconductors. Monoprice says that makes for more energy-efficient and responsive panels with less heat, more accurate colors, and faster response times.

On paper, the numbers look like a typical modern IPS gaming panel, with 1ms response times and 1,000-to-one static contrast. It's also VESA Display HDR 400 certified, so tops out at 400 nits for peak brightness. Monoprice pegs the color accuracy at 100 percent coverage of the Adobe RGB gamut, which is impressive for this class of display but doesn't quote DCI-P3 performance.

If you're wondering how this is all possible, a few corners have been cut. For starters, the build quality is patchy. It's a sleek-looking monitor, complete with slim bezels and a light smattering of RGB mood lighting. The stand looks crisp and sharp, but only offers basic tilt adjustment—there's no height adjustability or swivel. The main panel enclosure also feels cheap, thanks to coarse plastics which bend to the touch.

The feel and build quality are arguably less important in day-to-day use, but the low-rent ergonomics could prove more problematic. It's also worth noting that the USB-C interface only offers a maximum of 15W of charging power, which isn't going to get the job done for the vast majority of laptops.

Still, for most PC gamers, the DisplayPort 1.4 socket is most relevant. Monoprice has also included a trio of HDMI 2.0 sockets, so it has most bases covered and could make a good fit for monitor sharing with a console. Last on the cost-saving list is plain old VESA style adaptive sync rather than the AMD or Nvidia certified alternatives.

As for image quality, Monoprice includes three levels of user-configurable overdrive in the OSD menu. The fastest setting tips slightly into overshoot, but it's a quick display that will satisfy all but the most demanding esports pros in terms of both response and latency.

Our only real gripe when it comes to speed involves the full 180Hz refresh. That's a so-called 'overclocked' setting and, when enabled, both overdrive and adaptive sync are disabled. To access those features, you have to drop down to the default 165Hz. In practice, you'd be hard-pressed to notice the difference, but it's a slight annoyance that the advertised 180Hz comes with significant caveats.

Elsewhere, this is a vibrant and punchy panel, though possibly a touch too saturated. But, once you've tweaked the Windows display settings, SDR content looks great with the panel in HDR mode. In fact, we'd run it in HDR mode all the time to save having to jump between SDR and HDR modes, depending on content.

For the money, it's hard to argue with this monitor. As an all-round display for desktop duties and gaming, it isn't perfect, but it does represent outstanding value for money. **–JEREMY LAIRD**

VERDICT **9**

Monoprice Dark Matter 27-inch IGZO 180Hz Gaming Monitor

+ BY GRABTHAR'S HAMMER... Mega value for money; speedy and accurate image quality.

– ...WHAT A SAVING Cheap chassis; no height adjustment; weak USB-C charging.

$349, www.monoprice.com

SPECIFICATIONS

Panel size	27-inch
Panel type	IPS
Resolution	2,560 x 1,440
Brightness	400nits
Colour coverage	100% Adobe RGB
Refresh	185Hz
Contrast	1,000:1
Response	1ms
Inputs	3x HDMI 2.0, 1x DisplayPort 1.4, USB-C with DP 1.4 Alt Mode and 15W charging

Breathe in, breathe out.

NZXT H510 Flow

Compact Brilliance

AS YOU MAY KNOW, we're big fans of small cases here at *Maximum PC*. It's perhaps a bit of an Achilles heel of ours that we don't focus on the larger chassis out there. But there's just something about compact chassis that really hits home. For the vast majority who don't hoard TBs of data and process vast simulations or render video footage, a compact machine like this is all you really need. On-board audio killed the sound-card, Nvidia killed SLI, Intel killed networking cards, and the M.2 drive has decimated every other storage form. Because of that, for most people, a small case that you can lift off the ground and plonk on your desk is a smart move.

Typically that means a small form factor, but ITX cases are difficult to work with, they require special considerations during the build process, and it does limit your ability to expand it later on. On top of that, micro-ATX rigs, although stellar back in the day, have also gone the way of the woolly mammoth, so for the vast majority a small ATX mid-tower makes a lot of sense. It's a perfect compromise.

NZXT's H510 series of cases has been a popular pick for a long while now. The small compact design, with clean-cut lines, stylish color picks, tempered glass, and a host of design features to enhance your building experience has cemented this case as a fantastic budget(ish) option for anyone looking to build a new system.

The stock H510 comes in at $110, the H510i with included RGB lighting at $145, and the H510 Elite, the full tempered glass affair at $180. The one weakness these cases have, however, is airflow. A solid front panel might look great for those social media snaps of your setup, but it's hardly conducive to good cooling. These cases aren't without ventilation, the rear of the case has perforations along that edge, and there's a cutout underneath, but it's not quite what you'd call "airflow optimized". Enter the H510 Flow.

So what's new here? Technically, not much. The overall interior chassis is almost identical to the entire H510 line (technically the Elite's base chassis, as it has the solid metal plate running along the bottom of the front panel). You've still got a full-size PSU cover, still got the radiator bracket, the same cooling support, the cable tidy bar, and the smart cable routing in the back too. The material usage is pretty much the same as well, and there's the same support for storage also (a small 2 x 3.5-inch drive cage located in the bottom). Even the front I/O is the same, and there's still no support for vertical GPUs either.

The big difference is that front panel. With its significantly larger perforations, the intention is clear and simple—allow better access to cool air. Does it work? Absolutely. You can check out how well it performed in our build this month (see page 66), but needless to say, it's a marked improvement over its predecessors. If you want the best performance out of it, we'd recommend removing that front dust filter, but then you will have to clean it more often.

So while not a lot has changed, it didn't really need to. This is already an exceptional case, that doesn't require any major update. It still doesn't support vertical GPUs, but realistically, that's not a huge deal-breaker. And besides, to have a case of this caliber for $110, with an airflow option like this, that still looks as good as its solid panel siblings, well, yeah, it's just awesome. **–ZAK STOREY**

VERDICT
9
KICK ASS!

NZXT H510 Flow

+ FLOW STATE Good pricing; strong performance; intuitive design features; clean look.

– LETHARGIC No vertical GPU support; could use one more 120mm vent on the roof.

$110, www.nzxt.com

SPECIFICATIONS

Motherboard Support	ATX, Micro-ATX, ITX
2.5 / 3.5-inch Support	2+1
Max Radiator Support	280mm Front, 120mm Rear
Fan Support	2x 140/120mm Front, 1x 120/140mm Top, 1x 120mm rear
Dimensions	18.11 x 8.26 x 16.85 inches
Graphics Card Clearance	14.17 inches
CPU Tower Clearance	6.49 inches

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Razer Huntsman V2 Analog

Pure precision or gimmicky overkill?

EVEN THE SWITCHES on your keyboard can be a contentious issue. Some people prefer the old-school mechanical clicks that give you a real sense of feedback when typing, while others enjoy the softer, quieter, and more delicate type of keyboard that's often found on a laptop. Razer's Huntsman V2 analog appears to hit a sweet spot between the two.

The Huntsman lineup has always been a popular choice for PC enthusiasts, especially when it comes to gaming. The V2 Analog comes with a few bells and whistles, but are these important additions or simply unnecessary extras?

Those familiar with the full-size Huntsman style will notice that the V2 hasn't changed much in terms of layout from the Huntsman Elite model. In the top right are the media controls; three cylindrical buttons for the skip and play/pause controls. Next to that is the volume dial with a mute button in the middle. The wheel protrudes slightly out of the side so you can easily adjust the volume. It's slightly heavier than the Elite and feels significantly more sturdy. It also has a better grip, helping prevent the keyboard from slipping around on your desk.

The build quality on the V2 is superb. Though it features a mainly plastic construction, nothing feels cheap. Razer has increased the angle of the keyboard and while the original keyboards were flatter, the V2 offers stands if you want to increase this further. It makes for a comfortable angle for typing, even for all-day usage.

Razer has also thrown a wrist rest into the mix, which is similar to the one on the Elite. It loses the plastic surround, making it even more comfortable, and the plush and padded leatherette rest provide great comfort. Of course, the rest features RGB too, because, well... it's Razer, and it attaches to the keyboard by magnets. The Huntsman V2 comes with a main USB-C connection and a USB-A connection for powering the lights on the wrist rest. If you don't have a USB-C port, a type-A adapter is included in the box. Unfortunately, the braided cables aren't removable, but they seem pretty durable. It also offers a USB passthrough on the right of the keyboard.

LIGHT ENTERTAINMENT

The keys on this board are pretty sweet. They feature Razer's Doubleshot PBT caps and seem fairly durable. Razer's font is a decent typeface and one that is clean and sharp, however, it has one drawback. Due to its thin design, it lacks vibrancy when backlit as it doesn't exactly let the most amount of light through. With Razer's Chroma lighting being a big selling point of this keyboard, it seems a shame that the keys aren't the brightest.

The keys are pretty good on the whole but how about what's beneath? One of the standout features is the linear analog optical switches on this board. Great for gaming, these switches give you far more control. It has pressure-sensitive scaling inputs depending on how far the key is pushed, making them perfect for racing games. If you want to customize this further, Razer's Synapse software allows you to set actuation points between 1.5mm and 3.6mm.

Compared with the V1 Huntsman, the typing sound these switches produce is less of a high-pitched click and more of a satisfying deeper sound.

There is one thing that we have yet to mention and that is the price. This keyboard comes in at $250—that's expensive for any setup. However, for that hefty price, you get a keyboard with decent build quality and feel. It has a nice weight and stability to it, the wrist rest is better than before, and the keyboard provides great comfort on the whole.

We love the analog switches and the sound you get from typing away on this board, it provides nice deep feedback which won't get annoying over time as some louder switches can do. Razer has created a flagship keyboard, with more precision and speed over gimmicks, but for most people, that price tag will be a little overwhelming. –SAM LEWIS

VERDICT **8**

Razer Huntsman V2 Analog

ANALOG IS THE KEY Solid build quality; super speedy analog switches; sweet acoustics; comfortable design and wrist rest.

BACKSPACE Pricey board; permanent cables; not the brightest keys.

$249.99, www.razer.com

SPECIFICATIONS

Switch Type	Razer Analog Optical Switches
Switch Durability	100 million presses
Design Style	Full size
Connection	USB-C, USB-A (lighting)
Wrist-rest	Magnetic plush leatherette wrist rest
Weight	2.64lbs

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Corsair M65 RGB Ultra Wired Mouse

A modern take on a classic design

FOR CORSAIR, the M65 has gained a reputation as a legendary mouse. In the world of these perfect pixel pointers, the very name commands the same amount of respect as the Razer Deathadder, the Logitech G series, or SteelSeries' Sensei lineup. The M65 is the brand's quintessential mouse, unchanging, unflinching, and in a somewhat significant shake-up compared with the other three we just listed, rather unique in its design approach.

The shape of this mouse sets it apart from its competitors. Its wide angle and long, sweeping thumb rest give it a broad presence that you might assume would make it a sure shot for fingertip and claw gamers and yet, it's as equally at home with a palm-gripper too. It's comfortable and ergonomically impressive, there are no flared buttons or egg-shaped rears, just a clean-cut design, backed up by an impressive aluminum chassis. That's the way it always was, and we can happily report, that it hasn't changed one bit.

The M65 RGB Ultra has been designed very much along the lines of "if it ain't broke, don't fix it", and that's a philosophy we can get behind. The new model features the same weight tuning, the same RGB setup, and the same "sniper" button that has become synonymous with the series, but Corsair has taken the liberty of considerably ramping up the internal hardware quite drastically.

Let's start up with the switches. These are your classical OMRON optical affair, solid, reliable, pretty much the industry standard at this point. They last an eternity and provide a solid, responsive feel. However, Corsair has paired this with a neat bit of tech called 'Quickstrike'. Through the use of a spring tension system, it minimizes the gap between the primary mouse buttons and the switch to zero. There's also a marked improvement in total travel, meaning that when you are pressing down, this mouse is seriously quick on the click.

That might not sound that important, and arguably, in-game, unless you're an eSports god fragging scrubs to win that $1,000,000 prize pool, you're not going to notice it. However, for day-to-day use, it provides an incredibly enjoyable click. We can't explain it, but it simply feels lighter to the touch, quicker to press, and is noticeably quieter too—all of which rounds it out as being the nicest click (genuinely) we've ever used.

PARTY TRICKS

It's worth noting, however, that this is only reserved for the primary buttons, sadly the DPI switches, sniper switch, and back and forward switches on the side, still use the standard button setup.

Moving on from that, as we first saw from the Champion series and the K100 keyboard, the M65 also features that 8,000Hz hyper-polling, although we've still yet to see any in-game benefit from that, it's definitely there (although by default the mouse is configured to 1,000Hz). As for the sensor, it's a slightly tweaked PixArt PMW3392, in the form of Corsair's first Marksman 26K, giving you a top CPI of 26,000, a maximum tracking speed of 650 IPS, and tolerances of up to 50Gs of acceleration.

The real party trick, however, comes in the form of a six-axis gyro and accelerometer. You can now bind certain commands to the tilt of the mouse. We tried tying this into reloading in certain games by flicking the mouse upwards and, genuinely, it wasn't that bad. It takes time to train the muscle memory until it becomes an instinctive motion, but it can be useful if you're short of keybinds in *ARMA 3*, or *World of Warcraft*.

Ultimately, the Corsair M65 RGB Ultra is a fantastic and welcome new edition to the series. It provides a suite of new and impressive hardware without compromising on the mouse's original design. And for that reason alone, it has to be commended. **-ZAK STOREY**

VERDICT **9** KICK ASS!

Corsair M65 RGB Ultra Wired Mouse

+ FLAGSHIP Impeccable design; fits all grips; impressive sensor; quickstrike buttons are stunning.

- DINGHY Can get greasy; minimum requirements for hyper-polling.

$70, www.corsair.com

SPECIFICATIONS

Sensor Model	Corsair Marksman 26K
Max Sensitivity	26,000 CPI
IPS	600
Programmable Buttons	8
Weight	3.42-4.05oz (97-115g)

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PC GAMER

HyperX Cloud II Wireless

Durable, comfortable and a reliable timeless design.

THERE IS NO DENYING that HyperX's Cloud headsets are super comfortable, there's even a clue in the name. Although visually, this isn't the most advanced design, there is no faulting HyperX's formula here—take an already great gaming headset and add wireless functionality to the mix. So, does this headset live up to the latest expectations, and should you join sides with this formidable peripheral?

Starting with the design, HyperX has stuck with that old saying; 'if it ain't broke, don't fix it'. The mainly aluminum structure provides a durable build quality, while still having a flexible padded headband. As far as the cups go, if you have ever used HyperX headsets before, you'll already know, but these cans are soft and comfortable. A thick memory foam coats your ears and while back in 2015, the original Cloud IIs were one of the most comfortable gaming headsets on the market, we can still say the same today. They aren't the lightest headphones we've tested, but they are fine for a long session, with no noticeable pressure on your ears or head.

We mentioned that the design has remained similar through the years, and although we love the aviation-inspired look, it may not appeal to everyone. That's especially true for the red and black color scheme, which, unfortunately, is the only colorway for this model. Each cup has a shiny red HyperX logo in the center, you can find red stitching along with the headband, and of course, the headphone forks are in red aluminum. Other than this, the rest is black.

The majority of functions are on the left cup. There's a power button, mute button, USB-C charging port, and also the detachable microphone jack. To differentiate the two buttons, the power button is indented and the mute button is the opposite. This is great for mid-game changes when the last thing you want to do is turn your headset off when attempting to mute yourself.

The power button also acts as the virtual 7.1 surround button and you press it once to cycle on/off. On the right side is where the volume wheel is located, this has a nice texture to it for precise volume knob action. If we're being extremely picky, we'd prefer to see this on the left cup, so that you can make adjustments and keep your hand on the mouse when gaming.

The microphone is a detachable bendy mic that comes with an LED mute indicator on the end, which is a handy visual sign that your mic is muted, instead of thinking that your friends have been ignoring you for the last five minutes. The audio quality is nothing ground-breaking but will be more than decent for some party game chat.

Like most detachable headset mics, it's adequate, though it can be a little tinny at times. It does come with a foam filter that helps a little with this. However, if you are planning to live stream, a standalone mic will be the way to go.

SOUND ADVICE

Let's talk sound because this is what matters. This headset seems to hit a balanced sweet spot. You get a nice warm bass that isn't too in-your-face with these cans. It's there when you need it and it can hide away in intricate moments of gaming. The highs are detailed and they help to create a great audio aid with pinpoint directional sound when gaming. No one element of the soundstage overshadows the others, giving these headphones a well-balanced presence.

The virtual 7.1 surround also produces an immersive environment when gaming and watching films. This headset isn't the best for listening to music, and when the volume is cranked all the way up, the highs can get a little harsh, but they aren't necessarily made for music. Going wireless hasn't taken anything away from the originals, which is a positive.

The HyperX Cloud IIs aren't revolutionary, they aren't groundbreaking and they aren't anything brand spanking new. However, they are a slightly modern upgrade to an already great-sounding gaming headset. Sure, they only have one form of USB wireless connectivity that restricts compatibility, they aren't jam-packed with modern features and they may not be to everyone's visual taste. But what HyperX has created again is a no-fuss, reliable headset, with a great well-rounded sound and sublime comfort.

–SAM LEWIS

VERDICT **9**

HyperX Cloud II Wireless

+ UP IN THE CLOUDS Nicely balanced sound; pillow-like comfort; rugged build quality; classic aviation-inspired shape.

– STORMY TERRITORY Mediocre microphone; only one type of connectivity; distinctive red and black color scheme.

$149.99, www.hyperxgaming.com

SPECIFICATIONS

Driver Type	53mm dynamic driver w/ neodymium magnets
Frequency Response	15Hz-20,000Hz
Impedance	60ohms
Connectivity	2.4GHz wireless USB
Design Style	Circumaural, Closed back
Weight	0.68lbs

The fictitious Caribbean island of Yara... definitely not Cuba

FIRST-PERSON SHOOTER

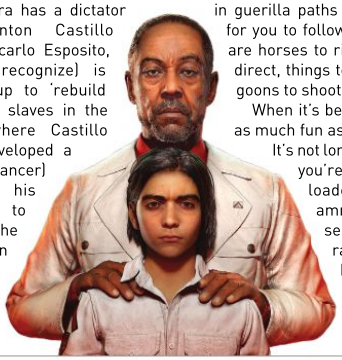
Far Cry 6

Over and over again, but Deathloop was last month

A MAN ONCE SPOKE at length about the definition of insanity. He defined it as doing the same thing over and over, expecting things to change. This time it's going to be different. This time it's going to be different. Welcome to *Far Cry 6*.

You went on to stab Vaas to death in *Far Cry 3*, but his monologue has continued to resonate. Every *Far Cry* since Vaas's has given you a wide-open play area, a madman, a bunch of buddies to help you out, and enough weaponry to outgun a *Just Cause* game. Every time we expect it to be different.

This time, it's definitely not Cuba. The fictional (and rather large) Caribbean island nation of Yara has a dictator problem, as Anton Castillo (portrayed by Giancarlo Esposito, whom you may recognize) is rounding people up to 'rebuild paradise' (work as slaves in the tobacco fields, where Castillo claims to have developed a smokable cure for cancer) while grooming his own runaway son to succeed him just as he succeeded his own father following the revolution.



Your character, a former soldier who can be either male or female, sets out to stop him. Following an unarmed opening in which you sneak through the backstreets and sewers of a city, you end up on a deserted beach via a sunken refugee ship. From there, you hook up with the local resistance, recruit an alligator, and, well, you know the rest.

The Caribbean setting recalls the first game in the series, whose sun-kissed beaches and frondy jungles set all this nonsense off in the first place. But while that game was distinctly level-based, this is a completely open world (at least once you get off the starting islet) covered in guerilla paths and grapple points for you to follow and exploit. There are horses to ride, animal allies to direct, things to find, and plenty of goons to shoot.

When it's being *Far Cry*, it's just as much fun as it has always been. It's not long into the game that you're toting two rifles loaded with different ammo types and are sent on a trip to a radio tower (groan) but this time it's just a waypoint—your real objective is to clear out a fort full of enemies (groan) who can call for help (groan). Complete this, and you're rewarded with a dubious case full of depleted uranium, which your arms dealing contact and guerilla wise old man Juan converts into a Supremo (and gives you a flamethrower too, just in case).

Supremos are overpowered weapons that you get one shot with before leaving them to recharge, which somehow happens as you kill people. Dani wears one on their back, and they can turn the tide of battle if used properly, often—especially in the case of the poison gas that can cause enemies to turn on each other—as a first-strike weapon.

AIMING FOR THE STARS

It's possible to mess up completely, of course, particularly as you can't easily aim the Supremo. We used one to open fire at a tank but ended up hitting the cliffside above, and vehicles are a real problem in the first stages of the game before you're handed a proper RPG. Get in one yourself, however, and you wonder how the AI troops manage—guns overheat too quickly, bullets fly in comically wide cones, and they move too quickly with steering that's not sensitive enough.

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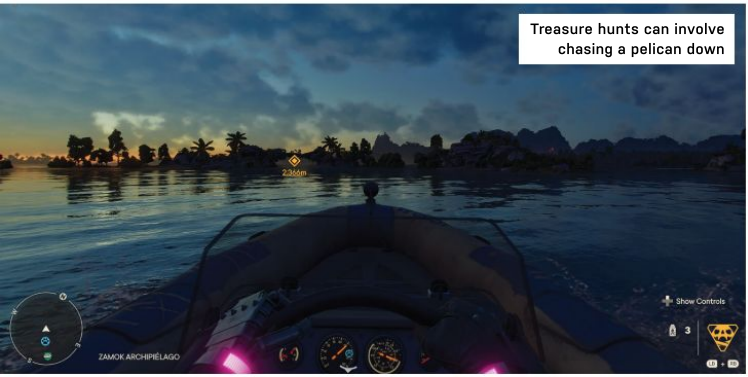
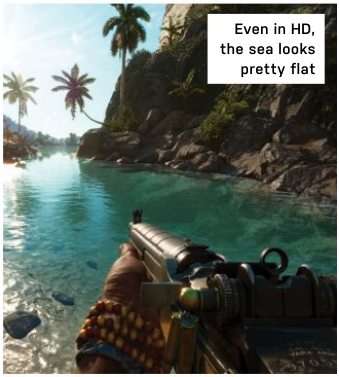
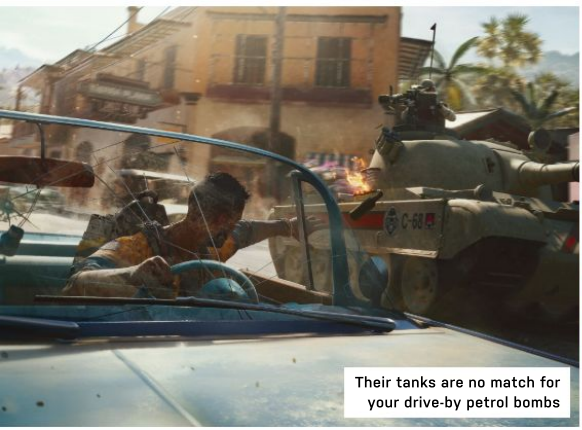
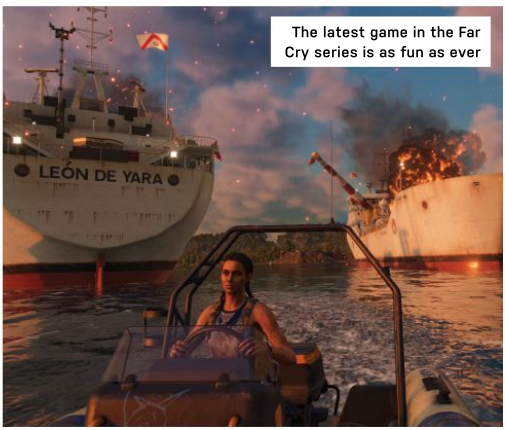


Treasure hunts can involve chasing a pelican down


Even in HD, the sea looks pretty flat


Their tanks are no match for your drive-by petrol bombs



The latest game in the Far Cry series is as fun as ever

Everything from *Far Cry 5* is here, including the treasure hunts that were a standout feature of that game. They're no less intricate but have widened their scope. One has us chasing a pelican across the map for a rifle, while another sees us pursuing a mongoose down the street trying to recover the key it's swallowed, which is hilarious, but the reward of a single pistol at the end of it is not. Especially as we're already packing Robocop's gun from the season pass rewards, an overpowered silenced pistol that fires bursts of armor-piercing ammo.

Unusually for a Ubisoft game, the performance is pretty bad. Our AMD Threadripper/RTX 3080 machine saw drops to 4fps that required restarts following fast travel, or just moving a finger near the screenshot button. We couldn't go near the high-res texture pack, which calls for 11GB of VRAM, presumably to freeze out the 3080. The game has AMD logos at the start, so the 16GB RX Cards are clearly in favor here.

Eventually, we reached a compromise, running at plain old 4K ultra with ray tracing on for reflections and shadows netted 50fps, and messing around with FidelityFX Super Resolution unlocked the magic next 10 frames.

Maybe it's just because we were annoyed that the superior HD textures were out of reach, but the game doesn't look that ultra. Even Esposito's chewing of the scenery lacks bite. Despite being broken by waves, the water is flat, the sand has the texture of a fiberglass pool liner, the trees seem repetitive, and we've come across floating rocks and seen things such as the textures on an alligator's nose suddenly drop to a much lower resolution. Things can flicker, which is annoying as certain objects are meant to flash to attract your attention. However, we are playing on code that arrived one day before release and, at the time of writing, hadn't been patched. So, it's possible that things may be different by the time you read this.

So what would Vaas make of *Far Cry 6*? Given that we discovered corpses under a bridge, executed using his signature 'tied to a rock and chucked in the water' method, we suspect he's around somewhere (he's returning for the DLC, along with villains from *Far Cry 4* and *5*). As for us, we're still doing the same things over and over, having a good time but starting to wonder if, just maybe, there's more to life than this. –IAN EVENDEN

VERDICT 7

Far Cry 6

PARADISE Lush tropical jungle; overpowered weapons; freedom to approach from any angle.

SACRIFICE Doesn't look as good as it could, especially on Nvidia; things are getting a bit familiar.

RECOMMENDED SPECS CPU, i7 7700 / Ryzen 5 3600X. RAM, 16GB. GPU, GTX 1080 / RX Vega 64 or better.

$69.99, farcry.com, M-rated

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LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Networking Whammy
> 5.25-inch Drive Cases
> DDR5 Upgrades

Router Review Improvements

Hello, I noticed in your review of the Asus ROG GS-AX5400 router that your ping times and upload speeds in wired mode were not so good. It seems as though the internet uplink with which it was tested is limited. It might have been better if you'd tested it in a corporate setting with faster upload speeds and better latency. That way, we could see what the limits are on the router.

I had to replace a Netgear router that was surprisingly bad with Wi-Fi speeds, even though its wired performance was good. By having your internet upload as the bottleneck, we'll never know whether the Wi-Fi has a decent performance both up and down.

Thanks as always for an informative and entertaining magazine. It was nice to see your article about quiet builds; that's one of my main areas of interest. The DDR 5 article was great, too. I love to see this kind of stuff because it helps me at work. Believe it or not, on our Dell servers, 850GiB/s NVME's are state-of-the-art—and those are the latest R640s! So the stuff you present is definitely a look into the future for me. The gaming gear is always leading edge. **–M. Schwager**

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: You raise some interesting points there, and I have to agree with you. It's one of the reasons why we've shied away from networking reviews over the years. Future is, understandably, wary about letting us plug routers into its networks directly. At our main offices, we have a separate "review" network upon which most of the *Maximum PC* machines are situated. Last time I checked, we still weren't allowed to pop routers on it for any length of time, due to potentially opening up security holes. Our IT department has always been strict on that.

The second reason is simply that we haven't been in the offices for any length of time. That said, as I'm departing, I'm going to hand the trusty Asus RT-AX88U over to the team and advise that they test it in the office. It hasn't got the best line, but you're 100 percent right, it will show whether there are any weak points in the router's configuration or hardware.

On the silent PC angle, I couldn't agree more. It has been a big driver behind my liquid-cooling pursuits over the years. I'm also glad you're enjoying the content. It's always difficult writing about things that haven't quite launched yet and trying to predict what's coming, but Christian did a great job with that piece.

Next issue is also our Tech Preview 2022 edition, where the team will be going into detail about what they expect to see in the future. Jarred is covering CPUs and GPUs, while Jeremy will be sorting out the storage and monitors, so that should be good!

Network Topics

Hi there! I love the magazine, and I'm a long-time subscriber. A reader recently requested reviews of Wi-Fi routers, and the response was, basically, "it's difficult". Things such as the home layout, construction materials, local interference, make results very user-specific.

So my suggestion is why not write a how-to on the methodology to test your Wi-Fi network for coverage, signal strength, or throughput? I have been thinning out my *Maximum PC* archives and stumbled across some good network articles from early 2013, called "Monitor your home network with NetWorx" and "Three steps to better broadband connection".

In the past, I've used NetStumbler to drive around searching for open Wi-Fi when it was not so prevalent. It also did decent bar graphs on signal strength as I roam about my own house. So, I would love to see an article that covers how to measure your bandwidth, signal strength, and coverage with tools such as NetStumbler/NetWorx or something more current; and also the steps you'd use to try and optimize coverage and throughput using these tools to adjust router positioning, antenna positioning, and whatever else you think would help.

Cleaning out more back issues in my library, I found

↘ submit your questions to: editor@maximumpc.com

a great network topic from February 2014, called "How We Test". This details how wireless access points were tested and mentions an open-source tool, Jperf, which sounds ideal for understanding throughput in various rooms and antenna positions. I wish there were more detail on using this tool, so I'd like to suggest an article on how to use it to test various network settings, channels, and antenna setups.

–D. Makris

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: Oh, I like this letter a lot! I remember using Jperf years ago. It might have been the former editor Alan who was teaching me to use it, but we definitely looked at it way back when.

Interestingly, in the next issue, Nick Peers is writing an eight-page feature on router settings, so this could be right up his alley for inclusion in that. I'll drop him a message and send your suggestion across. If he's already written it up, I'll slot it in for some time next year.

Heck, that's something I'll be reading like a hawk—both me and Storey Snr have been having networking trouble lately, so it's definitely something we could do with testing.

5.25-inch Cases?

Why don't you ever review cases with 5.25-inch drives anymore? Can't we get a list or a recommendation on this? Like seriously! What's going on?

–R. Romain

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: We get asked this question a lot more often than you'd think, and the reality is that there are very few new cases out there these days that support 5.25-inch drive bays.

Typically, PRs have a limited number of samples that they can ship out to journalists for review of each product. Often, these are pretty much all of the products from the last year. In many cases, it's difficult to get older products at all, even direct from the manufacturers (I should know, I've been trying to get my hands on an NZXT Manta for the past two years).

On top of that, the industry as a whole is moving away from discs and supporting 5.25-inch drive bays, as our media usage changes and evolves. As we typically move towards USB and digital as the primary media sources, some case manufacturers have stopped developing cases with drive bays. Removing the 5.25-inch drive bay allows for more compatibility with larger radiators, coolers, and the like. It also lends itself to sleeker designs and, of course, drives down manufacturing costs, which is another motivator for companies to ditch the trusty old slot.

There are still a few cases worth checking out, though. I'll list a few here that I'd personally take a look at if I needed a 5.25-inch bay. Although these might be some of the last cases out there that support that standard.

- be quiet! Dark Base Pro 900 Rev 2 ($270)
- Phanteks Enthoo Pro Tempered Glass ($130)
- Fractal Design Define R5 ($123)
- Fractal Design Define 7 ($170)
- Cooler Master Cosmos C700P ($367)
- be quiet! Pure Base 600 ($95)

These are cases I'd recommend if you're looking for a solid chassis. Fractal Design is a standout for me, and I imagine that it will likely be supporting the standard for some time. The Swedes are known for their practicality, and Fractal's cases epitomize that very attribute. But for the rest, it's not looking great going into the future.

For me personally, though, on the rare occasions that I need a disc drive, I've got a $20 USB disc drive rewriter from Amazon. But then again, I've always favored cooling and noise above all else.

Rendering Upgrades

I'm looking to build what may be my last computer; I'm 72 and keep my computers for about 10 years, and need some advice. My major use is video editing using Pinnacle Studio 24 Ultimate along with some auto-racing sims thrown in. I've got about 200 hours of video, mostly HI-8mm tapes, to import, edit and render to my NAS.

My current machine, i7-3770K CPU @ 3.50GHz w/16GB RAM + Nvidia GTX 970 works fine for importing the 8mm camera tapes, but the rendering of Full HD video is slow compared with SD rendering. I'm looking to gut my current system, keeping only the PS (SeaSonic SS-750KM3 750W), Case (Corsair Carbide), Cooling fans (my Phantek can fit an AM4 socket but will need to be replaced for any Intel or future AMD socket), and the GTX970 video card until new cards come down from the scalper's stratosphere.

If built today, I'm looking at a Ryzen 9 5900X, 2TB M2, 64GB+ RAM, 6-8TB HDD, but I won't build until next year, so what do you suggest, given my desire for the best performance during video editing? Should I wait for DDR5 and the next-gen of CPUs, or consider building now? My current system is fine, but can't be upgraded to Win 11 and is too slow for HD video rendering.

–M. Glinzak

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: I love letters like these, although yours made me rather sad. First up, let me just say, thank you for writing in and I truly hope you're around to see another PC build after this one.

However, this one is tricky for a number of reasons. Firstly, you're right, DDR5 would be a massive upgrade in terms of video rendering performance, particularly when upscaling to higher resolutions. I don't have any experience with Pinnacle Studio, but if it operates the same way as Final Cut Pro, Sony Vegas, or Premiere Pro, it's going to chew through cores, single-core performance, and memory frequency.

DDR5 starts out as a specification at 4,800MT/s (MHz, if you're in marketing) and goes up to a maximum of around 8,400. On top of that, it's doubling the capacity as well. It's already with reviewers, and the team here too as I write this, but I have my reservations. Mostly because usually within the first year or so of a new DDR standard, most BIOSes are unstable with it, and it's also ridiculously expensive. Intel's Alder Lake supports it as standard, and I imagine Ryzen's 6000 series chips will also do so next year.

I'd give it a month, then take a look at some of the reviews for Intel's Alder Lake platform, particularly *Tom's Hardware* and *Anandtech* (they're more likely to cover video rendering), and see how DDR5 performs there. As Alder Lake supports both DDR4 and DDR5, I imagine they will test with both and that should give you some idea as to what to do for your Ryzen upgrade in the future. I'll also recommend that the team plan a video rendering build for next year, so look out for that.

THE BUILDS

THIS MONTH'S STREET PRICES...

SO INTEL'S BUDGET BUILD this issue has seen quite the shakeup. With props to some recent sales, we see three initial swaps. Thanks again to a Samsung sale, we can slot in a Samsung 980 500GB SSD into the budget machine here, which is always a nice sight. At just an extra $6 from last time, we feel it's certainly worth it at this price.

Another change is our mobo, we switched this out from ASRock's B460M Steel Legend to MSI's B460M PRO-VDH WIFI model. This change is a whole $1 more, but because the ASRocks B460M Steel Legend is back up to $119, it is still technically cheaper.

CPU stocks for Intel are more stable so, thankfully, we have no shortage for our budget Intel build again. The Intel Core i3-10100 still sticks here for now but is $30 cheaper on a Newegg sale. Sure, it's almost two generations old, with the imminent release of the 12th-gen Alder Lake chips but, for a budget machine, the performance is all that you will need. Another slight performance increase, though, for the Intel side is the 16GB of Crucial Ballistix CL16 RAM. This has a speed of 3600MHz, so 400MHz greater than the previous Crucial Ballistix sticks we had, and for just an extra $10.

These RAM sticks also find their way into the AMD build, taking the speed up from 3200MHz to 3600MHz. Along with this change, a new chip is introduced to the AMD side, the Ryzen 5 3600. Our previous Ryzen 3 3100 is out of stock and, at just $20 more, this is a great upgrade. With six cores instead of four and also an extra four threads, this CPU seems like a worthwhile swap on paper.

With this 3rd-gen chip and motherboard supporting PCIe 4, the SSD remains the same on the AMD build. We thought about swapping it out for the Samsung 980 found on the Intel side, but that is only PCIe 3.0. The standard hard drive storage and PSUs on both budget builds for this issue. One last thing to mention is the dreaded GPUs. Yep, still overpriced on the second-hand market and near enough impossible to buy new. Same BS, different day.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	500W EVGA BA 80+ Bronze	$50	
Mobo	ASRock B550 Phantom Gaming 4/ac AM4 NEW	$100	
CPU	AMD Ryzen 5 3600 NEW	$225	
GPU	AMD Radeon RX 6700 XT 12GB NO STOCK	$480	$840
RAM	16GB (2x8GB) Crucial Ballistix CL16 @ 3600MHz NEW	$85	
SSD	512GB XPG GAMMIX S50 Lite PCIe 4.0 M.2 SSD	$70	
HDD	1TB WD Blue 1TB 7200	$40	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,177 or $1,537**	

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	500W ARESGAME AVG500 80+ Bronze	$50	
Mobo	MSI B460M PRO-VDH WIFI Micro ATX LGA1200 NEW	$109	
CPU	Intel Core i3-10100	$130	
GPU	Nvidia GeForce RTX 3060 12GB NO STOCK	$330	$700
RAM	16GB (2x8GB) Crucial Ballistix CL16 @ 3600MHz NEW	$85	
SSD	500GB Samsung 980 NVME M.2 PCIe 3.0 SSD NEW	$60	
HDD	1TB WD Blue 1TB 7200	$40	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$931 or $1,301**	

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STARTING WITH some of the more basic parts on these two mid-range builds, we have the same PSUs being introduced. These are Corsair's 650W RM 80+ Gold power supplies, which provide more than enough power for both of these builds. This change sees a price decrease of $30 on the AMD side and $15 on the Intel machine, whilst providing the same wattage and efficiency. Another part we see in both machines is an increase from 1TB of HDD to 2TB with WD's Blue 7200 drive hitting a nice tasty sale down from $70 to $47!

Talking of sales, the AMD build gets a change of CPU cooler, a limited-time promo on Newegg brings this larger 280mm cooler down from $94 to a handsome $55. On the flip side, the CPU cooler on the Intel PC has risen back up to $80. Still, it's a solid cooler for this price, so it stays. The CPUs on each build also remain and with a sale on our Intel Core i7-11700K, it is now a respectable $345 instead of $400 last issue. This brings it closer to AMD's price for its Ryzen 5 5600X, but it's still the cheaper of the two, even with a recent $10 increase. These fluctuating prices are driving us crazy!

GPUs also drive us mad. You can pick up some 3070s for a minimum of $1000, but that's criminal. The same goes for the Radeon RX 6800 XT GPU, which starts at an even heftier $1500. In slightly better news, we have a few price changes for the AMD build. The trusty ASUS TUF Gaming X570 mobo is still a great board and is made even better by being $5 cheaper. Better still is the $7 drop for the RAM sticks. It's not much, but any decrease is welcome.

For Intel's RAM, we have swapped out the Kingston FURY Renegades for some Corsair Vengeance sticks. These are running at the same speed (3600MHz) and give us some RGB. We had to swap these out as, at the time of writing, we couldn't find any of the Fury Renegades that ran at 3600MHz, only 3200MHz. Finally, the ASRock Z590M PRO4 mobo on team Intel was luckily in a sale, bringing it down to $130. If only it stayed at this price.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$150	
PSU	650W Corsair RM (2019) 80+ Gold **NEW**	$80	
Mobo	Asus AM4 TUF Gaming X570 -Plus WiFi	$195	
CPU	AMD Ryzen 5 5600X	$309	
Cooler	280mm Cooler Master Masterliquid ML280 RGB **NEW**	$55	
GPU	Nvidia GeForce RTX 3070 8GB **NO STOCK**	$500	$1,150
RAM	16GB (2x 8GB) Team Vulcan Z CL18 @ 3600MHz	$60	
SSD	500GB Samsung 980 Pro NVME M.2 PCIe 4.0 SSD	$110	
HDD	2TB WD Blue 7200 HDD **NEW**	$47	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,538 or $2,188**	

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$150	
PSU	650W Corsair RM (2019) 80+ Gold **NEW**	$80	
Mobo	ASRock Z590M PRO4	$130	
CPU	Intel Core i7-11700K	$345	
Cooler	Enermax Liqmax III 240 RGB	$80	
GPU	AMD Radeon RX 6800 XT 16GB **NO STOCK**	$650	$1,560
RAM	16GB (2 x 8GB) Corsair Vengeance RGB Pro SL RGB CL18 @ 3600MHz **NEW**	$99	
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0	$90	
HDD	2TB WD Blue 7200 HDD	$47	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,703 or $2,613**	

LAST TIME AROUND, it worked out better for both turbo builds that we chose two 3TB hard disk drives from Western Digital as this was cheaper than buying one 6TB HDD. However, the stars have aligned and, thanks to another Newegg sale, our builds can benefit. Western Digital's Blue 6TB HDD is on sale at $110, which works out cheaper than two 3TB drives. For our main storage, we have stuck with the same speedy PCIe 4.0 SSD's for both Intel and AMD turbo builds. These are great drives, both with 1TB of storage. On the AMD turbo machine, the price of the Samsung 980 Pro seems to have stabilized, only being $8 more this time. The Gigabyte Aorus Gen4 7000s SSD for the Intel PC price hasn't—it now costs $20 more.

The big change for the AMD rig is a swap of motherboards. Out goes the MSI MPG X570 Gaming Edge Wi-Fi and in goes Gigabyte's X570 GAMING X. MSI's board was no longer on offer and is nearly $30 more expensive than Gigabyte's alternative. Both are great boards, but we are sticking with the more sensible choice for now.

Not many changes have been made on the Turbo builds overall. We can't wait to add Alder Lake chips to our top-tier Intel build but, for now, we're sticking with the monster Intel Core i9-11900K chip. Although it has risen in price by $20, it's still one of the best Intel processors. AMD's Ryzen 7 5800X is equally impressive and deserves its spot in the AMD turbo build. At just under $400, it is nearly $150 cheaper than Intel's offering. Other than the mobo and HDD, everything else remains the same for team AMD, though Corsair's iCUE H150i ELITE CAPELLIX AIO 360mm rises by $20.

On the Intel rig, there was just one alteration, other than the HDD. The Fractal Design Ion PSU from the previous issue was out of stock, resulting in a change to Corsair's RM (2019) falling into the machine. A cheaper unit with the same specification, it made sense to fit it in, even though this is far from the budget build. Last but not least, GPU issues. Yes, we sound like a broken record, but we can't recommend paying the extra. It's your decision, of course, but at more than double the RRP, that makes us quake in our boots.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$160	
PSU	750W NZXT C750 80+ Gold	$123	
Mobo	Gigabyte X570 GAMING X **NEW**	$188	
CPU	AMD Ryzen 7 5800X	$394	
Cooler	Corsair iCUE H150i ELITE CAPELLIX AIO 360mm	$190	
GPU	Nvidia GeForce RTX 3080 10GB **NO STOCK**	$700	$1,650
RAM	32GB (2x 16GB) G.Skill Ripjaws V 32GB @ 4000MHz	$137	
SSD	1TB Samsung 980 Pro M.2 PCIe 4.0	$185	
HDD	6TB WD Blue 5400 HDD **NEW**	$110	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$2,219 or $3,169**	

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$160	
PSU	750W Corsair RM (2019) 80+ Gold **NEW**	$109	
Mobo	MSI MAG Z590 Tomahawk Wi-Fi	$220	
CPU	Intel Core i9-11900K	$545	
Cooler	MSI MAG CoreLiquid 360R AIO	$140	
GPU	AMD Radeon RX 6900 XT 16GB **NO STOCK**	$999	$1,600
RAM	32GB (2x 16GB) G.Skill Trident Z Neo @ 4000MHz	$170	
SSD	1TB Gigabyte Aorus Gen4 7000s M.2 PCIe 4.0	$190	
HDD	6TB WD Blue 5400 HDD **NEW**	$110	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$2,675 or $3,276**	

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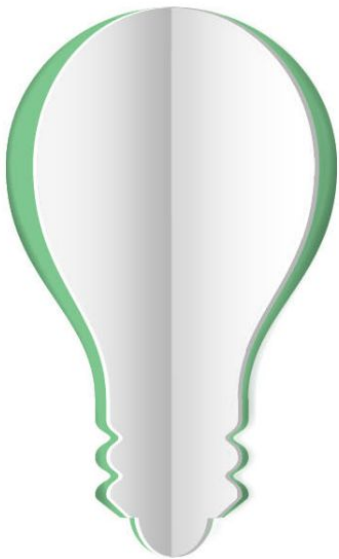

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